STORM DRAINAGE SYSTEM DESIGN

Technical Design Manual #3

Chandler ✦ Arizona

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Section 1
Introduction

This manual has been prepared as a guide for preparation of plans for stormwater drainage systems to be installed within the City of Chandler (City). This manual along with the City's *Standard Specification and Details, the Maricopa Association of Governments (MAG) Standard Specifications and Details*, and the publications *Drainage Design Manual for Maricopa County, Arizona, Volume I Hydrology and Volume II Hydraulics* by the Flood Control District of Maricopa County (FCDMC) should provide all of the information needed for plan preparation. The *Drainage Design Manual for Maricopa County, Arizona, Volume I Hydrology and Volume II Hydraulics* have been adopted by the City as a basis for design guidance and criteria, except as amended herein.

1.1 Storm Drainage Policy and Standards

1. The City Engineer shall require for review and approval the submittal of a Drainage Report wherever development and or grading is proposed within the City limits. Development shall mean any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling.

2. The City Engineer shall require for review and approval a conceptual stormwater collection and retention plan be submitted with a preliminary plat or site development plan, and approved prior to the approval of such plat or plan. Drawings, plats, plans, etc. shall comply with the City *Engineering - General Information* standards. The stormwater plan shall include, but not be limited to, the following:

    a. The watershed boundaries, both on-site and off-site, shall be delineated on the drainage map. Indicate any existing drainage or irrigation structures such as waste or delivery ditches, natural drainage channels, etc., and the proposed development's impact on existing features.

    b. A topographic map which shows the location of the project area; a 1- or 2-foot contour interval must be used as the base map for both existing and proposed. The map must also show the location of the property with respect to the street system and other features such as existing and proposed stormwater retention basins, RWCD Canal, Consolidated Canal, etc.

    c. Method of collection (surface and/or subsurface).

    d. Depth, side slopes, and volume of retention basins.

    e. Calculations showing retention required and provided.

    f. Method of disposal of water within 36 hours.

    g. Areas tributary to each retention basin.

h. Discuss the development's low outfall elevation and location relative to City datum. Indicate location on all watershed and topographic maps.

i. Indicate the drainage pattern of all streets within and adjacent to the proposed development on the drainage map.

j. Present a preliminary retention basin plan including size, depth, and possible methods of draining the retention basin.

k. Indicate areas within the 100-year floodplain.

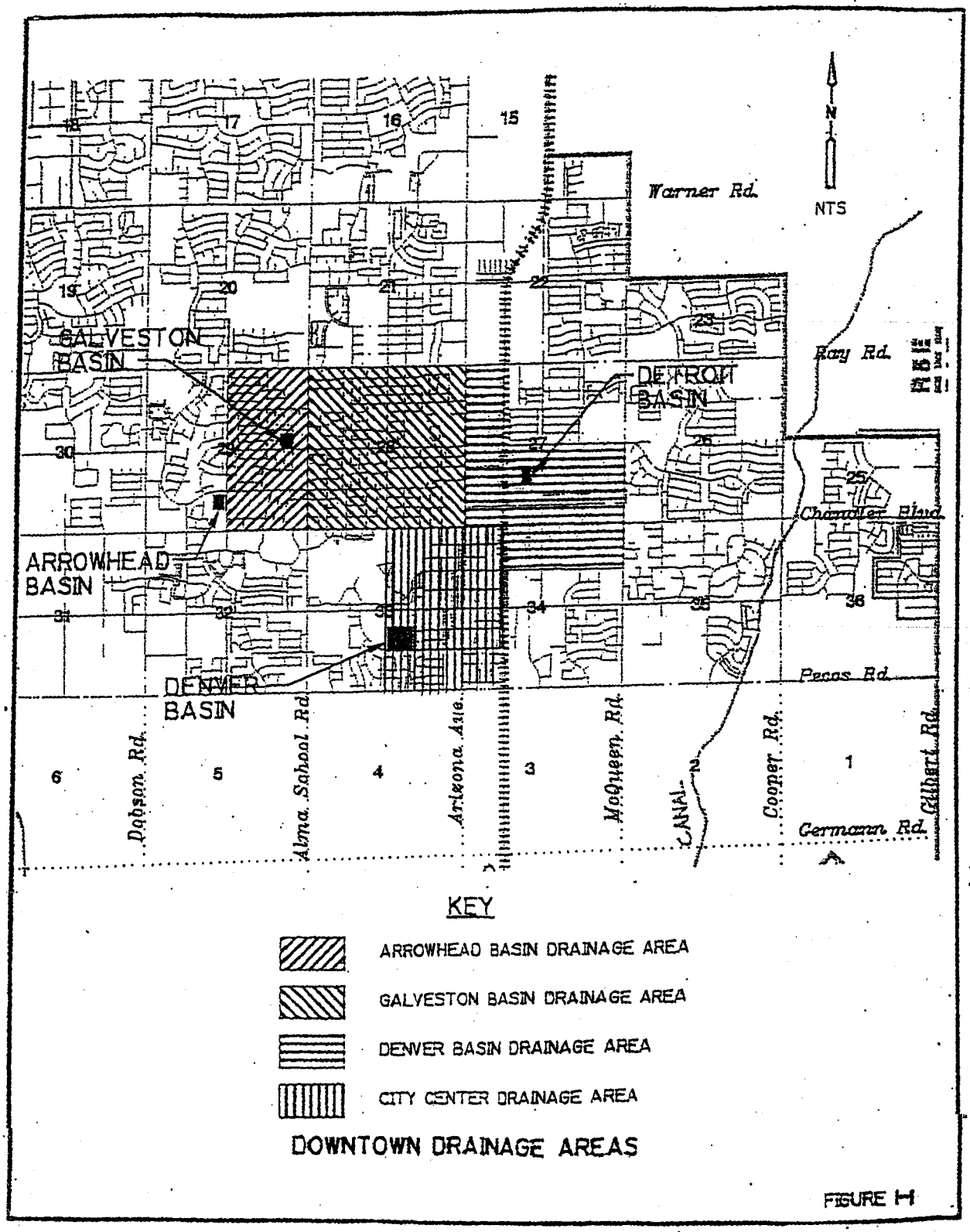
3. All stormwater which falls within a subdivision or site, including the respective one-half of all abutting streets, resulting from a 100-year, 2-hour storm (2.6 inches) shall be retained within the boundaries of said subdivision or site. Design standards necessary to achieve the requirements are set forth in this manual. In the downtown area of the City, identified in Figure 1-1, storm drains and areawide retention basins have been constructed. In these areas, the City has reduced retention requirements, See Section 5.

4. All retention basins shall have a design capacity such that the water depth is limited to a maximum of three (3) feet resulting from a 100-year, 2-hour storm. The City Engineer may approve a greater water depth when a positive method of water disposal, such as pumping facilities, is available and under control of the City or other government agency. Additional requirements regarding the retention basin volume and freeboard are described in Section 5 of this manual. Side slopes shall not be steeper than 4:1 (horizonal:vertical). Exceptions to slope requirements may be approved by the City Engineer when innovative and esthetically pleasing design features are presented and public safety is not compromised.

5. Changes or additions to sites which require approval of a site development plan shall be required to address drainage on the entire site and meet storm drainage requirements as set forth in this chapter for the complete site.

6. A drainage easement shall be prepared and recorded for permanent stormwater retention basins.

Figure 1-1 Downtown Drainage Areas



7. All retention basins that will be maintained by the City shall be improved by the developer per City guidelines for retention basin development and installed prior to the City's acceptance of the retention. Retention basins, when not privately maintained, shall be dedicated to the City in fee title as stormwater retention basins or drainage rights-of-way. In the case where private retention basins receive water, other than that which falls upon the property and adjacent streets and/or alleys, the areas shall be designated as easement areas for retention purposes and shall have a recorded restrictive covenant requiring perpetual maintenance.

8. Initial shallow pit percolation tests shall be performed in retention areas to determine natural percolation. Tests shall be conducted prior to mass grading and results shall be submitted to the City Engineer prior to approval of drainage plans.

9. Drywells are permitted to drain surface retention areas only when no other means of disposal are available. Infiltration into the drywell cannot be considered to reduce the size of the retention area. The property owner of record shall be responsible for the performance, operation, registration, and maintenance of drywells used with on-site retention. Each drywell must penetrate at least 10 feet into a permeable stratum and a drywell percolation test must be carried out on the drywell before acceptance. The drywell percolation test results are to be filed with the City Engineer. In the event drywells are anticipated, the initial infiltration rate used for design purposes shall be 0.1 cfs per drywell. All drywells designed at this flow rate shall be shown on the plans. At the time of construction, the drywell disposal rating for each drywell shall be 50 percent of the tested percolation rate, however, in no case will the stormwater disposal rate for any drywell exceed 0.5 cfs.

10. Off-site flows entering the development as a result of the 100-year storm shall be accounted for in the conceptual stormwater collection and retention plan, but are not required to be included in the retention volume requirements. The point of entry and exit for off-site flows from the 100-year storm shall not be altered by the site development from the existing condition. In the case where off-site flows are directed to a retention basin, or the basin watershed is located within the 100-year flood plain, the basin water depth shall not exceed 4'-0" for the 100-year storm.

11. Finished floor elevations must be 14 inches above the lot, drainage sub-area, and development low-outfall elevation. Positive drainage shall be provided for individual lots in the development site - minimum 0.50 percent slope unless on-lot retention is provided.

12. Existing drainage ditches must be tiled, abandoned, piped, or improved when a new development is built across or around a canal.

13. Stormwater plans for subdivisions which are located in whole or in part within a Federal Emergency Management Authority (FEMA) 100-year flood zone shall be submitted to the FCDMC and approved by FCDMC prior to approval by the City. FCDMC requires building final floor elevations to be a minimum of 12-inches above the 100-year flood level. See Item #10 above. In no case shall any finished floor elevation be less than 14 inches above the flood plain low outfall elevation.

14. Constructed underground retention storage structures shall have a minimum 50-year service life. Underground structures constructed of coated and/or galvanized ferrous metal shall have a minimum average soil side service life of 50 years. Underground retention storage structures are only allowed in commercial and industrial areas.

15. An As-Built Grading and Drainage Plan shall be submitted for approval by the City upon completion of the site development work.

1.2 Definitions

Detention System: A system which delays runoff in a controlled manner through the use of temporary storage facilities.

Retention System: A system which contains and disposes of runoff in a controlled manner through the use of storage and disposal facilities.

Low Outfall Elevation: Lowest lot, sub-area and/or regional elevation outfall for the ultimate design of the street/development. A development's low flow outfall elevation may be in the street.

Off-Site Flows: Stormwater flows reaching the development or site from outside the area of the development. Include sheet flow from vacant lands and along roadways, or overflows from canals and retention basins.

1.3 Standard Specifications and Details

The *MAG Standard Specifications and Standard Details* have been adopted by the City. The City also publishes its own supplement. Stormwater collection system details are included in the *City of Chandler Standard Detail Manual*. The City's special requirements relative to storm drainage systems are as follows:

1. Scupper: City Standard Detail C-500 shall be used in place of MAG Standard Details #203 and #206.

2. Roll-Type Curbs: Use MAG Standard Detail #220 Type C for all roll-type curb and gutter installations.

3. Catch Basins: Use MAG Standard Detail #533-1. Catch basin grate shall be MAG Standard Detail #540-1, Type TW-1.1. Minimum V depth shall be 3 feet 6 inches. Curb and gutter transition shall be per MAG Standard Detail #532.

4. Valley Gutter: Use City Standard Detail C-233.

5. Drywell System Detail and Specifications: Use City Standard Details C-501 or C-502.

6. Catch Basin Access Frame and Cover: MAG Standard Detail #536-2 and City Standard Detail C-505 shall be used in lieu of access opening depicted in MAG Standard Details #536 and #536-1.

7. Retention Basin Inlet: City Standard Detail C-504 replaces MAG Standard Detail #537.

8. Below Grade Retention Basin Inlet (Bubbler Box): Use City Standard Detail C-507, pages 1, 2, & 3.

9. Handrail Detail: Use City Standard Detail C-107.

10. Shallow Pit Percolation Test Requirements: Use City Standard Detail C-109.

11. Trash Rack Access Barrier: City Standard Detail C-503.

12. Headwalls: Use MAG Specification 501-1.

1.4 Drainage Report

A Drainage Report shall be submitted for approval by the City with the site improvement plans. The report shall be typewritten on letter size sheets with necessary maps folded and inserted into the report in the proper order.

All elevations shown on the plans shall be referenced to a benchmark on the City datum unless otherwise approved by the City Engineer.

The Drainage Report shall include:

1. Cover sheet:

    a. With submittal number, name, and address of project, parcel, or development for which the report is submitted.

    b. Name, address, and phone number of engineer and property owner.

2. A narrative with topographic maps that describe the location and condition of the property the project is located on (on-site conditions); and the upstream (off-site) watersheds as well as any downstream constraints which affect the property.

3. Provide calculations demonstrating required retention volume, tributary areas to each basin, and volume provided. Indicate basin grades, depth, high water elevation, pipe invert elevations, basin outfall elevation, and side slopes.

4. Provide elevation and indicate location of low outfall elevation for the development, sub area or site improvement.

5. Describe the effect of a basin overflow due to back-to-back storms or a storm greater than the design storm.

6. Provide street capacity calculations for the 10-year and 50-year storm.

7. Provide time of concentration calculations.

8. Provide storm drain piping and catch basin hydraulic calculations.

9. Indicate the routing of off-site flows through or around the proposed development.

10. Indicate the City datum benchmark to which all site and facility elevations are referenced.

11. Indicate tailwater and backwater elevations at all culverts.

12. Indicate finished floor elevations of all structures.

13. Indicate method of disposing of retained stormwater within 36 hours, and provide shallow pit percolation test results and calculations.

14. Indicate inflow and outflow points at retention/detention basins and culverts.

15. Indicate points of concentration and intake point for catch basins, scuppers, channels, and street intersections.

16. Calculations of the number of drywells, per City criteria.

17. Drainage report based upon computerized hydraulic models shall have all values and variables identified in the report. Software manuals and documentation shall be made available upon request by the City.

18. Long-term maintenance responsibility: Specify the name, address, and phone number(s) of the person(s), firm(s), or agency responsible for ownership, operation, liability, and maintenance of drainage improvements. List other documents where these responsibilities are documented (i.e., CCRs, final plats, etc.).

19. Catch basin V-depth calculations.

20. The following calculations as required:

    a. Calculations for earth-load and HS-20 live-load on buried pipe. Calculations for required pipe strength (D-Load on reinforced concrete pipe).

    b. Channel hydraulics.

    c. Special structures.

1.5 Improvement Plans

All site improvement plans shall be prepared and signed by a Professional Engineer who is qualified and registered by the State of Arizona to practice in the particular field of competency required by the type of improvements. Plans shall be submitted on 24" x 36" sheets. The plans shall be drawn to an engineering scale. Engineering scale requirements are 1" = 20' or 1" = 40'. Architectural scales are not allowed. A landscaping plan for retention basins shall be submitted with the improvement plans. Landscaping shall comply with the Zoning Code.

Improvement plans shall comply with these other City Design Standards:

1. Zoning Code
2. Grading and Drainage Plan Review Checklist
3. Conceptual Engineering Site Review Checklist
4. Civil Site Plan Review Checklist

1.6 As-Built Grading and Drainage Plan

Following completion of storm drainage improvements, an As-Built final grading plan shall be submitted to the City of Chandler Public Works Engineering Division. The plan shall be sealed by a Civil Engineer and a Registered Land Surveyor each registered in the State of Arizona. Plans shall be marked As-Built with all changes noted. As-Built drawings shall contain the following:

1. Certification of catch basin inlet and outlet elevations.

2. Certification of retention basin dimensions, grades, volumes, and side slopes.

3. Certification of retention basin percolation rate, both the pre-construction and the post-construction shallow pit percolation tests shall be submitted.

4. Approved ADEQ drywell registration, drilling logs, and certified testing results.

5. Show the As-Built maximum water depth of the retention basin for a 100-year, 2-hour storm.

6. Show the As-Built finished floor elevation of buildings and or building pads and the As-Built elevation of the development low outfall.

7. Present final plan for carrying runoff from outside the proposed development (through or around the development).

Section 2
Hydrology

2.1 Rainfall Intensity

City of Chandler Standard Duration Rainfall Intensity Curves for the 10, 50, and 100-year storms are provided in Appendix A. The curves reflect local City rainfall. These curves reflect a mean of results calculated for west, central, and south Chandler and shall be used in the preparation of drainage system designs within the City.

2.2 Estimating Runoff

The Rational Method shall be used to estimate runoff when the drainage area is less than 160 acres with fairly uniform land use. For larger more complex watersheds or drainage networks, a rainfall-runoff model shall be developed.

$$Q = CIA \quad \textbf{(2-1)}$$

where:
Q = Peak discharge (cfs).
C = Runoff coefficient value from City of Chandler Runoff Coefficient Tables 2.1 and 2.2 in Section 2.
I = Intensity value (inches/hour) based on *City of Chandler Storm Duration Rainfall Intensity Curve*.
A = Size of tributary area (acres)

Velocities based on full curb flow shall be used to establish flow times:

where: **(2-2)**
Ti = Initial lot runoff time
Tt = Travel time
Tc = Time of concentration (minutes)
Tc = Ti + Tt
Tt = LF/(V*60)
LF = Length of flow from furthest point upstream or outlet at initial lot, in feet - whichever is less
V = Velocity (full curb flow), feet per second, based on Mannings Equation, see Section 3.

In residential areas use ten (10) minutes for the initial time. For industrial, commercial, and cluster developments use five (5) minutes for initial runoff time. For street flow calculations, initial lot runoff time is zero:

$$Tc = 10 + (LF/(V*60) \text{ residential} \quad \textbf{(2-3)}$$
$$Tc = 5 + (LF/V*60) \text{ industrial, commercial, and cluster} \quad \textbf{(2-4)}$$
$$Tc = 0 + (LF/V*60) \text{ street flow only} \quad \textbf{(2-5)}$$

Tc calculations based on the Papadakis and Kazan Equation will not be acceptable.

The following runoff coefficients shall be used.

Table 2-1 ***Runoff Coefficients for the Rational Method***	
Surface	***C***
Farm Land	0.10
Grass Lawn (average slope 0-7%)	0.20
Bare Ground (undeveloped vacant lots)	0.25
Grass Lawn (average slope > 7%)	0.35
Undeveloped Desert	0.50
Playgrounds	0.60
Desert or Rock Landscaping	0.50
Retention Basins (areas below H.W.L.)	1.0
Impermeable Surfaces (pavement, roofs, etc.)	0.95

Table 2-2 ***Weighted Runoff Coefficient***	
Area	***C***
Commercial or Industrial	0.90
Multi-Family	0.80
Detached Single Family	0.65
Cluster Developments	0.75

2.3 Manning's Equation

For hydraulic calculations utilizing Manning's Equation for street and pipe flow, the following roughness coefficients shall be used.

Table 2-3 ***Mannings Roughness Coefficients (n)***	
Streets	
Concrete Gutter (Troweled Finish)	0.012
Asphalt Pavement -- Smooth -- Rough	 0.013 0.016
Concrete Curb with Asphalt Pavement -- Smooth -- Rough	 0.013 0.015
Concrete Pavement -- Float Finish -- Broom Finish	 0.014 0.016
Storm Drain Piping/Channels	
Corrugated Metal Pipe	0.024
Formed Unfinished Concrete	0.017
Vitrified Clay Pipe	0.014
Concrete Pipe	0.013
HDPE	0.011
Cement Mortared Surfaces	0.013
Concrete Lined Channel	0.014
PVC Pipe	0.011

Section 3
Street Drainage

3.1 Street Flow

The Street Drainage criteria of Section 3 of the *Drainage Manual for Maricopa County, Volume II Hydraulics* shall apply except as amended herein. The rational method shall be used to calculate street runoff.

Calculations shall be submitted which indicate compliance with the following criteria:

1. 10-Year Storm:

- No curb overtopping as indicated in Figure 3-1. For major collector and arterial streets with four or more total lanes, at least one traffic lane must be free of water in each direction.
- Arterials require a dry 12' lane in each direction.
- Major collectors & collectors require minimum of 12' dry lane down middle.
- Major collectors & collectors with median require dry lane in each direction.
- Minor collectors can have flow to top of curb, no requirement for dry lane

2. 50-Year Storm:

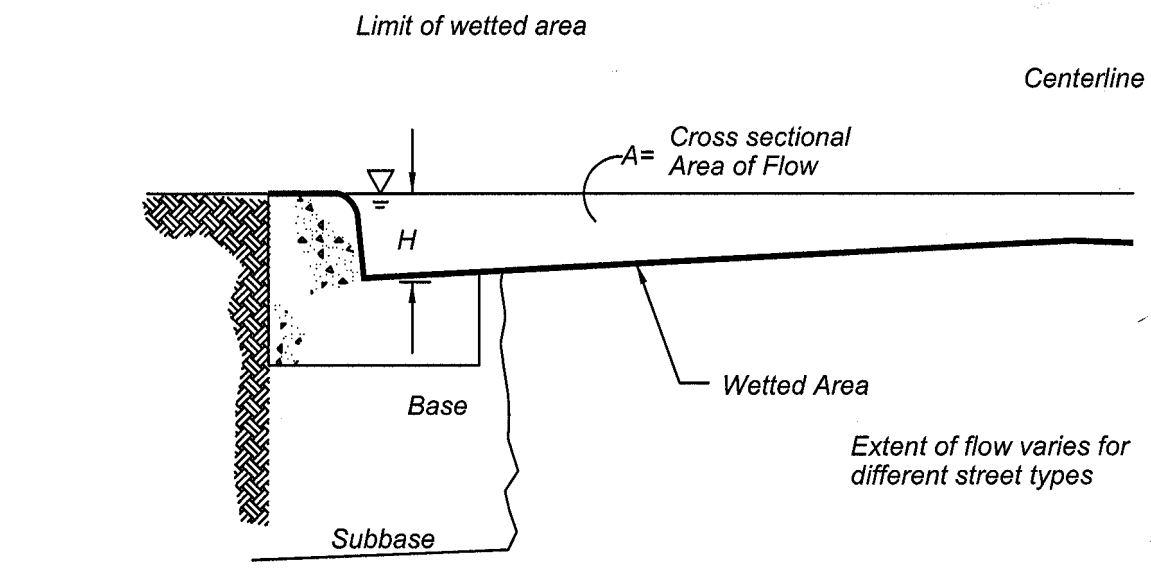
- Calculated flow must be considered to be contained within the right-of-way width.

  - ✔ 0.3 feet maximum depth over the curb
  - ✔ 100 cfs maximum flow
  - ✔ 10 fps maximum velocity
  - ✔ Wetted perimeter length shall not exceed the distance from back of sidewalk to back of sidewalk

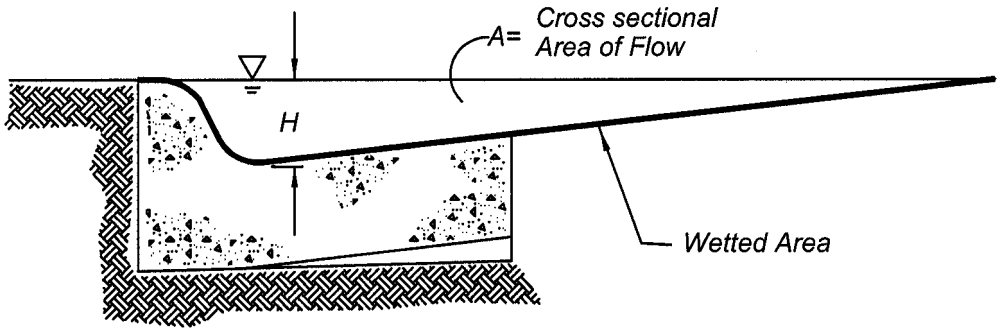
3. 100-Year Storm:

- Calculated flow must be considered to be contained within the right-of-way with:

  - ✔ 6 inch maximum depth over the curb
  - ✔ 100 cfs maximum flow
  - ✔ 10 fps maximum velocity
  - ✔ Wetted perimeter length shall not exceed the distance from back of sidewalk to back of sidewalk



Vertical Curb



Roll Curb

Figure 3-1
Cross Sectional Areas for Vertical and Roll Curbs

To calculate the flow capacity of a gutter, use the type and size of gutter and street to calculate flow area and hydraulic radius per the street flow limitations of this section. Street flow capacity shall be calculated using Manning's Equation. Hydraulic data for City standard street profiles are provided in Table 3-1. For non-standard street profiles, calculations should be based on the FCDMC manual.

A 7-inch curb may be allowed to increase the street capacity and eliminate the need for storm drains. It requires the approval of the City Engineer and may only be used for short sections of streets near drain inlets. Slotted drains will only be allowed if the grating is of the **removable type**. Inverted crown streets are not allowed.

Table 3-1
Calculated Hydraulic Characteristics for One-Half Street Flow to Top of Curb

Street Type	*Type*	*H (in)*	*A (sq ft)*	*Wetted Perimeter (ft)*	*Hydraulic Radius*	*City of Chandler Std. Detail*	*MAG Std. Detail*	*No. Dry Driving Lanes*
Local	Vertical	6	5.60	17.42	0.3215	C-212	220 A	0
Local	Vertical	7	7.04	17.50	0.402	C-212	220 A	0
Local	Roll	4	2.93	17.54	0.167	C-212	220 C	0
Residential Collector	Vertical	6	6.17	22.42	0.275	C-210	220 A	0
Industrial Collector	Vertical	6	3.99	20.32	0.196	C-208	220 A	1
Minor Arterial	Vertical	6	3.84	17.86	0.215	C-205	220 A	1
Phased Major Arterial	Vertical	6	3.84	17.86	0.215	C-204	220 A	1
Major Arterial	Vertical	6	4.99	20.42	0.244	C-203	220 A	1

Note: Cross Slope = 2% for local and collector streets and 2.5% for arterial streets
H = Curb Height
A = Cross Sectional Area of Flow

Show roadway widths for above.

Section 4
Storm Drains

4.1 General

All stormwater pipe installed under roadways, driveways, or other pavement subject to vehicular traffic shall be designed to withstand HS-20 wheel loading, minimum pipe sizes are 15-inch diameter for laterals and 18-inch diameter for mains, where storm drains are subject to wheel loads.

Storm drains shall be located per the Standard Utility Location Details provided in the City of Chandler Standard Details. Maintain 6'-0" horizontal separation between storm drain lines, water lines, and sewer lines.

Curved storm drain lines may be accepted for drains 24 inch and larger.

Maximum manhole spacing shall be 400 feet.

4.2 Storm Drain Hydraulics

Calculations for establishing the hydraulic grade line (HGL) for storm drainage catch basins, pipes, and structures are to be submitted with the engineering improvement plans. The HGL shall be shown on storm drain piping profile drawings, including catch basin runs.

Hydraulic calculations shall be prepared as indicated in the FCDMC Hydraulic Manual with the following modifications:

1. Storm drain piping should be sized to carry the excess runoff to meet the storm street flow criteria described in Section 3.

2. Where a storm drain is the sole flow path to a retention basin from a development or site improvement, the storm drain shall be sized to carry the 100-year storm peak flow rate.

3. Where there is no supplemental flow way to accommodate the difference between the 10-year and 100-year storm for conveyance to retention basins, the storm drain shall be designed to accept the difference between the 10-year and 100-year storms.

4. For minor storm drains, as defined herein, approximate methods, as outlined herein, may be used to establish the system hydraulic grade line (H.G.L.).

To minimize backwater effects, the rise in backwater elevation on the upstream side of a culvert shall not exceed 3 feet when the drainage in question does not include flood plain flows. Where flood plain flows are involved the backwater depth shall not exceed 4 feet. Any increase in floodplain width caused by the roadway and/or culvert shall remain within a public drainage easement and shall not reduce the minimum allowable difference between the 100-year water surface elevation and the finished floor elevation of any existing or proposed residential, commercial, or industrial building.

The City categorizes storm drain systems as major storm drains and minor storm drains based upon the following criteria:

1. **Major Storm Drain:** Includes storm drain piping 24-inch in diameter and larger, and all storm drain pipes greater than 400 feet long.

2. **Minor Storm Drain:** Includes all storm drain piping less than 24-inch in diameter and/or less than 400 feet in length. On-site equalization pipes may be 12-inch minimum unless otherwise allowed by the City Engineer, but in no case shall a pipe be smaller than 10-inch diameter.

4.3 Water Surface Profile Calculations

Water surface profile calculations shall comply with the Section 4.3 of the FCDMC Hydraulics Manual except as modified herein. Calculations for headlosses in storm drain systems shall use the headloss factors and simplifications provided below.

4.3.1 Pipe Headlosses

Pipe Friction Slope (Sf) as described in FCDMC Section 4.3 may be simplified as:

Sf = Slope of pipe invert for minor storm drains
Sf = $\frac{Q^2}{K^2}$ for major storm drains **(4-1)**

As used here the term (K) is called Conveyance, where:

A = Area of Pipe in square feet
R = Hydraulic Radius in feet
Q = Discharge, cfs
n = Manning's "n"

$$K = \frac{1.486}{n} AR^{0.667} \quad \textbf{(4-2)}$$

4.3.2 Minor Headlosses

Factors for calculating minor headlosses, k values are provided in Table 4-1. These values are utilized in the equation:

Where: h_l = headloss, feet
v = flow velocity, fps
g = acceleration due to gravity (32.2 fps²)

$$h_l = k \times \frac{v^2}{2g} \qquad \textbf{(4-3)}$$

For minor storm drainage systems, the assumed headlosses provided in Table 4-1 are adequate.

Table 4-1
Calculations for Minor Headloss

	Major Storm Drain		***Minor Storm Drain***
Structure or Condition	***Change in EGL***	***Change in HGL***	***Change in HGL***
Bubbler Outlet Box	0.20	0.20	N.A.
Submerged Pipe Outlet	1.00	0.00	N.A.
Non-submerged Pipe Outlet	1.00	0.00	0
C.B. Outlet Pipe, round end	0.20	1.20	1.2
C.B. Outlet Pipe, square end	0.50	1.50	1.5
C.B. Inlet Pipe	1.00	0.00	0
Junction Structure	Not Used	Not Used	Not Used
M.H., 1 Inlet, w/o deflection *	0.05	0.05	0.05 ft.
M.H., 1 Inlet w/deflection *	FCDMC Fig 4.7	FCDMC Fig. 4.7	0.10 ft.
M.H., 2 Inlets *	2.00xFCDMC Fig.	2.00xFCDMC Fig. 4.7	0.20 ft.
M.H., 3 Inlets *	3.00xFCDMC Fig.	3.00xFCDMC Fig. 4.7	0.30 ft.
Transition Structure	FCDMC Sec 4.3.3.2	FCDMC Sec 4.3.3.2	Ignore
Bend Loss (Curved Pipe)	FCDMC Fig 4.7	FCDMC Fig 4.7	Ignore
Friction Loss in Pipe	Sf x L	Sf x L	Sf is parallel to invert

* No change in pipe size of the mainline major storm drain. If there is a change in pipe size of the mainline major storm drain, see note 2.

Notes:

1. Unless otherwise shown, the above coefficients are "k" values to be applied to the velocity head of the pipe being investigated. Where the flows in pipes have different velocities, use the highest velocity.

2. Where transitions occur at manholes, combine both the transition loss and the manhole loss to determine the total head loss. The flow velocities in the mainline storm drain (inlet and outlet pipes) are used in the Transition Structure calculation. The flow velocity in a pipe discharging from a catch basin into a manhole may be used only in the M.H. calculation and only if it is the highest velocity. The "k" value used in the Transition Structure calculation for change in pipe size within a manhole is obtained from FCDMC Table 4.3 for an enlargement, the usual case, and from FCDMC Table 4.4 for a contraction.

3. L is the length of the storm drain pipe, in feet.

4. Sf is the friction slope as described in Sec. 4.3.1, herein.

4.4 Catch Basins

Catch basins shall comply with Section 3.3 of the FCDMC Hydraulics Manual except as amended herein. Catch basins shall be per MAG Standard Detail #533-1, and the grating shall be MAG Standard Detail #540-1, Type TW1.1. For all catch basins, the depth of water in the basin for the 10-year storm shall not be higher than 0.5' below the lip of the inlet as demonstrated by hydraulic calculations. Minimum V-depth should be 3'-6", calculations shall be provided for establishing required V-depth as indicated below. Where S is in degrees.

1. For single catch basins as shown in Figure 4-1, V-depth is calculated as:

$$V = CF + FB + 1.2\frac{v^2}{2g} + \frac{d}{Cos(S)} \qquad \textbf{(4-4)}$$

2. For catch basins in series as shown in Figure 4-1, V-depth is calculated as:

$$V_1 = CF_1 + FB + 1.2\frac{v_1^{\ 2}}{2g} + \frac{d}{Cos(S_1)} \qquad \textbf{(4-5)}$$

$$V_2 = CF_1 - G + FB_1 + H_1 + 1.2\frac{v_2^{\ 2}}{2g} + \frac{d_2}{Cos(S_2)} \qquad \textbf{(4-6)}$$

The freeboard provided for the second catch basin shall not be less than 0.5 feet unless otherwise approved by the City Engineer, and shall be calculated as follows:

$$FB_2 = V_2 - \frac{d_2}{Cos(S_2)} - 1.2\frac{v_2^{\ 2}}{2g} - CF_2 \qquad \textbf{(4-7)}$$

The connector pipe between catch basins in series shall be checked for adverse slope by the following relationship:

$$V_2 - 0.5 > V_1 - G \qquad \textbf{(4-8)}$$

The maximum number of inlets in series shall not exceed two (2) unless otherwise approved by the City Engineer.

Symbol Definitions:

V	=	Depth of the catch basin, or V-depth, measured in feet from the invert of the connector pipe to the top of the curb.
CF	=	Vertical dimension of the curb face at the catch basin opening, in feet (includes local depression).
v	=	Average velocity of flow in the connector pipe, in feet per second, assuming a full pipe section.
d	=	Diameter of connector pipe, in feet.
S	=	Slope of connector pipe.
FB	=	Freeboard (0.5 ft, unless otherwise approved by the City Engineer).
H	=	Connecting pipe headloss in feet as calculated per Sec. 4.3 herein.
H_1	=	Connecting pipe headloss between catch basins in series.
H_2	=	Connecting pipe headloss between last catch basins in series and storm drain.
G	=	Difference in elevation of the tops of curb of catch basin in series.
H_j	=	Junction loss in if connector pipe outlets into a manhole, substitute loss.

(The term $1.2\ v^2/2g$ includes an entrance loss of 0.2 of the velocity head.)

3. Additional catch basin requirements are described below:

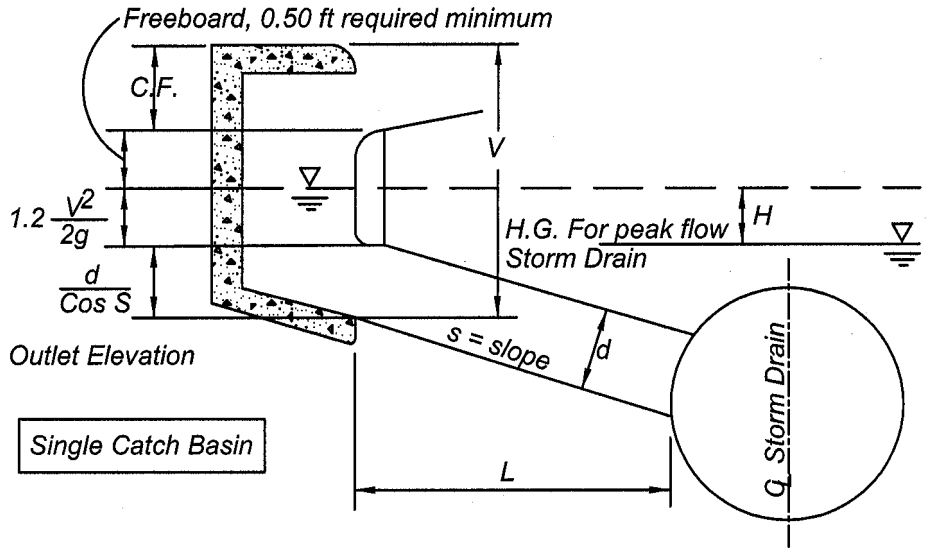
   a. To calculate the interception capacities for catch basins along roadways, use the weir equation from the FCDMC manual for a 10-year storm. The orifice equation may be used for storms longer than the 10-year storms if appropriate and it can be demonstrated that the inlet is submerged.

   b. Bubbler boxes should have a 60-inch wide opening for maintenance access unless otherwise approved by the City Engineer. See City Standard Detail C-507.

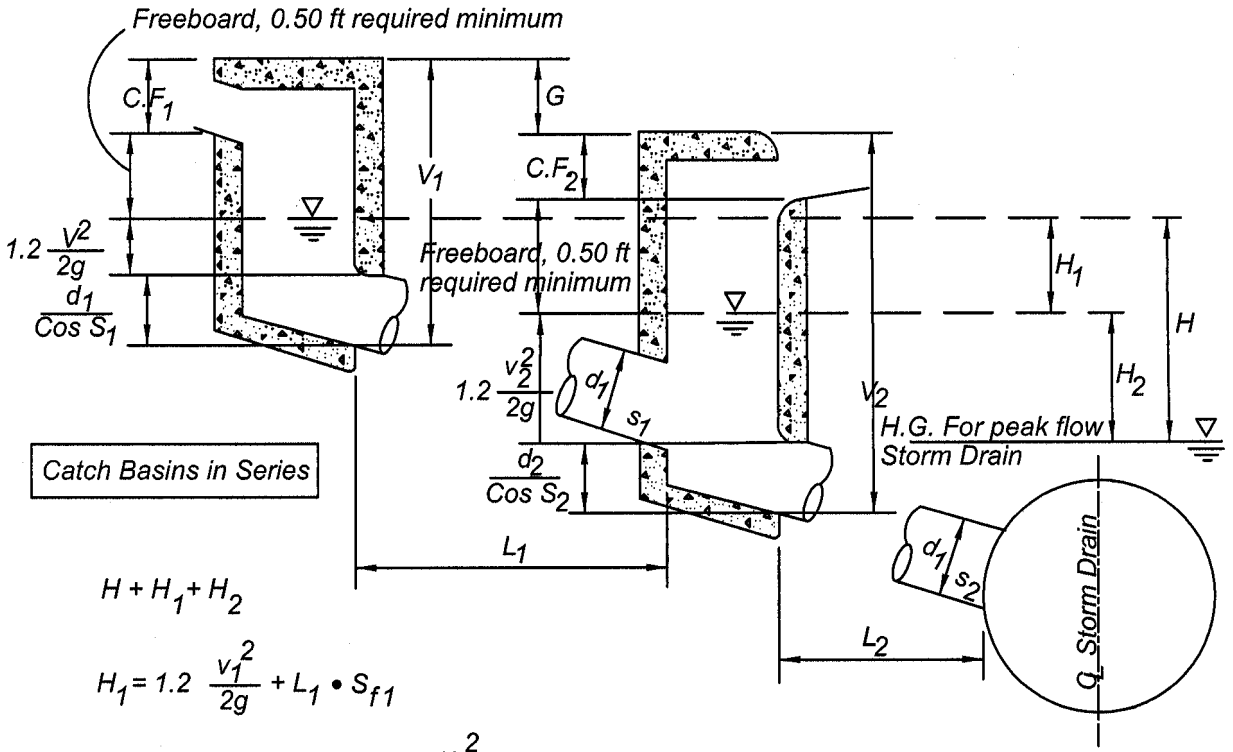
   c. In the FCDMC Manual equation for the interception capacity of a depressed curb-opening inlet operating as a weir, d = depth at curb measured from the normal cross slope, in feet.

   d. Account for clogging of combination inlets by ignoring the grate and applying a factor of 80 percent to the total curb opening.

   e. Maximum curb opening depth shall be 6 inches.



$$H = H_j + L \bullet S + 1.2 \frac{V^2}{2g}$$



$$H + H_1 + H_2$$

$$H_1 = 1.2 \frac{v_1^2}{2g} + L_1 \bullet S_{f1}$$

$$H_2 = H_j + L_2 \bullet S_{f2} + 1.2 \frac{v_1^2}{2g}$$

Figure 4-1
Catch Basins

4.5 Open Channel Flow

The shape and slope of drainage channels in open public areas should follow safety factors for depth and velocity. See Section 6 of the FCDMC *Drainage Design Manual, Volume II Hydraulics.*

The open channel flow is based upon the following criteria:

1. Maximum channel depth (d) is 3 feet
2. Maximum channel velocity (v) = 4 fps

Open channels are not allowed in the City Right of Way. Open channels shall be designed to convey at least the 100-year peak discharge within the main channel.
Channel lining, freeboard, toe protection, under drains, design velocity shall be as shown in Section 6 of FCDMC Drainage Design Manual, Volume II Hydraulics.

4.6 Acceptable Piping Materials

Selection of piping materials for storm drains shall comply with the requirements of this section unless otherwise approved by the City Engineer. Calculations indicating anticipated loadings, pipe class, or strength shall be submitted with the Drainage Report. For non-rigid pipe, calculations indicating anticipated deflection shall be prepared in accordance with the manufacturer's performance data and design standards and shall also be submitted with the Drainage Report.

1. Corrugated High Density Polyethylene Plastic Pipe (CHDPEP):

   a. Specification: MAG Standard Specifications # 738 and # 603.
   For use under local/residential streets, Section 603.4.2 is revised to read: The bedding material shall conform to section 728 of MAG Specifications for a 1-sack slurry mix, except that 1/2-sack of Portland cement (one sack = 94 pounds) is acceptable in the mix and shall provide a minimum of one (1) foot cover over the top of the pipe.

   b. Size Limits: 18 to 48 inch diameter (smooth interior lining).

   c. Soil Conditions: Soil pH of 1.25 to 14.

   d. Joints: Water tight

   e. Soil Cover: One (1) foot minimum under flexible pavement, two (2) foot minimum under construction traffic. Maximum depth of cover is ten (10) feet..

   f. Compaction Methods: Mechanical compaction methods required, no jetting or flooding allowed.

   g. **Not for use in arterial street Right-of-Way or under collector street pavement.**

   h. Special inspection required during installation of pipe and pipe zone bedding materials.

2. Non-Reinforced Cast-in-Place Concrete Pipe (NRCIPCP):

   a. Reinforced Cast-in-Place Specification: MAG Standard Specification #620, ACI-346.

   b. Size Limitation: 30 inch through 120 inch.

   c. Soil Conditions: Soil pH>5.

   d. Soil Cover: 1-foot minimum.

   e. Joints: N/A.

   f. Location Limitations: **Not allowed in Public Right of Way or locations subject to traffic loads.** Proposed locations must have a permanent drainage easement.

   g. Pressure Limitations: Hydraulic grade line must be below the crown of the pipe.

   h. Special inspection required for trench bottom preparation, concrete placement, concrete curing, and backfill.

   i. Hydraulic calculations shall use a Manning's n = 0.014

3. Rubber Gasketed Reinforced Concrete Pipe (RGRCP):

   a. Specification: MAG Standard Specification #735.

   b. Size Limitations: Minimum diameter 18 inches, 15 inches allowed for equalization pipes.

   c. Soil Conditions: Soil pH>5, if pH<5 then specify Type 5 cement and provide bituminous coating.

   d. Joints: Rubber gaskets per MAG Standard Specification #765.

   e. Location Limitations: **None**.

   f. Pressure Limitations: Per manufacturer recommendations.

   g. Pipe Class shall not be less than indicated in Table 4-2.

4.7 Alternative Piping Materials for On-Site Drainage

For on site storm drain or equalizer pipes from retention basin to retention or to drywells, corrugated metal pipe or polyethylene C-900 pipe material may be used, as long as it is not within the Public Right of Way. Corrugated pipe shall have a 50-year life and both alternate materials in the traffic areas shall be designed to withstand H-20 wheel load.

Table 4-2

Pipe Diameter (inches)	***Depth of Cover in Feet (From bottom of base course)***							
	< 1'	***1'-3'***	***3'-5'***	***5'-8'***	***8'-11'***	***11'-15'***	***15'-20'***	***20'-25'***
15	V	IV	II	II	IV	IV	V	V
18	IV	IV	II	II	III	IV	V	V
21	IV	IV	II	II	III	IV	IV	V
24	IV	III	II	II	III	IV	IV	V
30	III	III	II	II	III	IV	IV	V
36	III	IV	II	II	III	IV	IV	V
42	II	II	II	II	III	IV	IV	V
48	II	II	II	II	III	IV	IV	V
54	II	II	II	II	III	IV	IV	V
60	II	II	II	II	III	IV	IV	V
66	II	II	II	II	III	IV	IV	V
72	II	II	II	II	III	IV	IV	V
78	II	II	II	II	III	IV	IV	--
84	II	II	II	II	III	IV	IV	--
90	II	II	II	II	III	II	--	--
96	II	II	II	II	III	II	--	--

Note: Based upon worst case trench and non trench conditions.
Loads - AASHTO HS-20.
ASTM C-76, B-wall circular pipe.

Section 5
Detention/Retention

5.1 Retention Basin Locations

Permanent retention basins are not allowed within the public right-of-way. However, in redevelopment areas where on-site retention is not possible and represents an extreme hardship, the City Engineer may waive or modify this requirement.

5.2 Retention Calculations

Retention calculations shall be submitted as follows:

$$V_R = \frac{D}{12} AC(1.1)$$

where:

V_R = Retention volume required, cubic feet
D = 100-year, 2-hour depth of rainfall, inches (2.6 inches)
A = Area of project, including one-half of all abutting streets, square feet
C = Runoff coefficient (per table 2.1 or 2.2)
1.1 = Additional 10%

Typical runoff coefficients are provided in Section 2. The weighted runoff coefficients provided in Table 2.2 may be used instead of the values provided in Table 2.1 if the City Engineer does not request highly detailed calculations. Drywell volumes shall not be included in proposed storage capacities. The area used to calculate the volume of the basin may be calculated as the mean of the top and bottom areas provided that side slopes are of uniform slope. Anticipated percolation volume during the storm duration shall not be used to decrease the required detention volume.

In the downtown area of the City, identified in Figure 1-1, storm drains and areawide retention basins have been constructed. In these areas, the City has reduced retention requirements. Values of the depth of rainfall for the calculated retention volume within these areas are given in Table 5.1. Zero values signify existing retention basins are adequately sized to serve the area.

Table 5-1 *Reduced Depth of Rainfall for Downtown Area*	
Drainage Area	***D (inches)***
Denver Basin	Zero
Galveston Basin	1.2
Arrowhead Basin	Zero
City Center	Zero*

*Note: See Figure 1.1 for location of drainage areas.

*Developments within the City center storm drainage area shall be required to participate in the City center storm drain system.

5.3 Retention Basins

Retention basins shall be sized to store the 100-year, 2-hour storm runoff plus an **additional 10 percent** to account for losses due to sedimentation, sloughing of side slopes, and weed growth.

Shallow pit percolation tests shall be performed in retention areas to determine natural percolation. Test results shall be submitted to the City Engineer prior to approval of drainage plans.
All retention basins shall have a design capacity such that water depth is limited to a maximum of 3 feet resulting from a 100-year, 2-hour storm. The City Engineer may approve a greater water depth when a positive method of water disposal, such as pumping facilities, is available and under the control of the City or another governmental agency. Side slopes shall not be steeper than 4:1 (horizontal: vertical). Exceptions to slope requirements may be approved by the City Engineer when innovative and aesthetically pleasing design features are presented and public safety is not compromised. Vertical retaining walls at retention basin are not allowed along any public street frontage unless allowed by the director of Planning and Development. Retention basins must be configured to provide access to the basin bottom for maintenance vehicles.

Lakes or permanently filled ponds used for stormwater collection will be required to meet all retention basin requirements specified herein except for water depth, drainage time, and side slopes below the normal water level. Appearance of retention basin shall be per the zoning code. Drywell inlet grates shall be 2-inches above the bottom elevation of retention basins. Retention basin bottoms shall not be turfed in areas of high sediment buildup (near inlets and drywells). Depressed sediment traps at inlets and drywells shall be provided.

Spillways and stormwater pipe shall be designed to discharge into retention basins at least 0.5-foot above the bottom of the basin with a sediment trap. All stormwater pipe ends shall be terminated with trash racks, per C.O.C. Std. Detail C-503. Sizes greater than or equal to 12" will require handrails.

Facilities such as playgrounds, tennis courts, or others located in the bottom of retention basins shall be elevated above the 10-year ponding elevation, a suggested basin configuration is provided in Figure 5-1. Calculations demonstrating the depth of 10-year ponding shall be included in a drainage report where such facilities are proposed. Calculations for provided capacities shall account for any landscape berming and facilities which are to be located within the retention basin. Swimming pools are not accepted within the boundaries of any retention basin. Paved parking is not accepted within boundaries of retention basins located in residential areas. Stormwater retention may be allowed in paved parking areas in commercial and industrial areas provided that the maximum depth of water for the 100-year, 2-hour storm is 6 inches and that each parking space remains dry to the drivers door (one-third front to two-thirds rear).

In the event that a storm drain pipe system is necessary and headroom requirements are such that the inlet to the retention pond must enter below the bottom of the retention pond, the following requirements must be followed:

1. The storm drain pipe may be connected to the interceptor chamber of the City-approved drywell installation if the chamber is large enough, otherwise a below grade retention basin inlet (bubbler box) is required.

2. The flowline of the storm drain inlet pipe invert elevation shall be at, or higher than, the interceptor chamber overflow elevation. The pipe connecting a bubbler box to an inceptor chamber shall be below the storm drain invert elevation of the bubbler box.

3. The capacity of the interceptor or bubbler box grate shall be determined and discussed in the drainage report. The head required for the flow, including pipe, junction, and other losses shall not exceed the depression line of the catch basin curb opening. The hydraulic gradeline must be shown in the profile on the pipe construction plans. The water surface depth used to calculate the hydraulic grade line should be based on the depth of water resulting from a 10-year storm, or approximately 1.5 inches of runoff.

4. In the event that the capacity of the interceptor chamber grate is inadequate or the storm drain pipe is too large for the 48-inch interceptor, a catch basin complying with City Standards shall be used as a bubbler box. An 8-inch diameter drain pipe shall be connected to the interceptor chamber of the City-approved drywell installation. The connection shall be from the catch basin flowline to the interceptor chamber overflow elevation or higher. A minimum slope of 2 percent must be maintained on the connector pipe.

5. For stormwater basins with a piped outlet, a sediment trap shall be provided at the entrance to the outlet pipe. The sediment trap shall provide 300 cubic feet of sediment storage volume for each acre of basin area.

6. Equalization pipe shall be 12" minimum per 4.2 Minor Storm Drain, page 17.

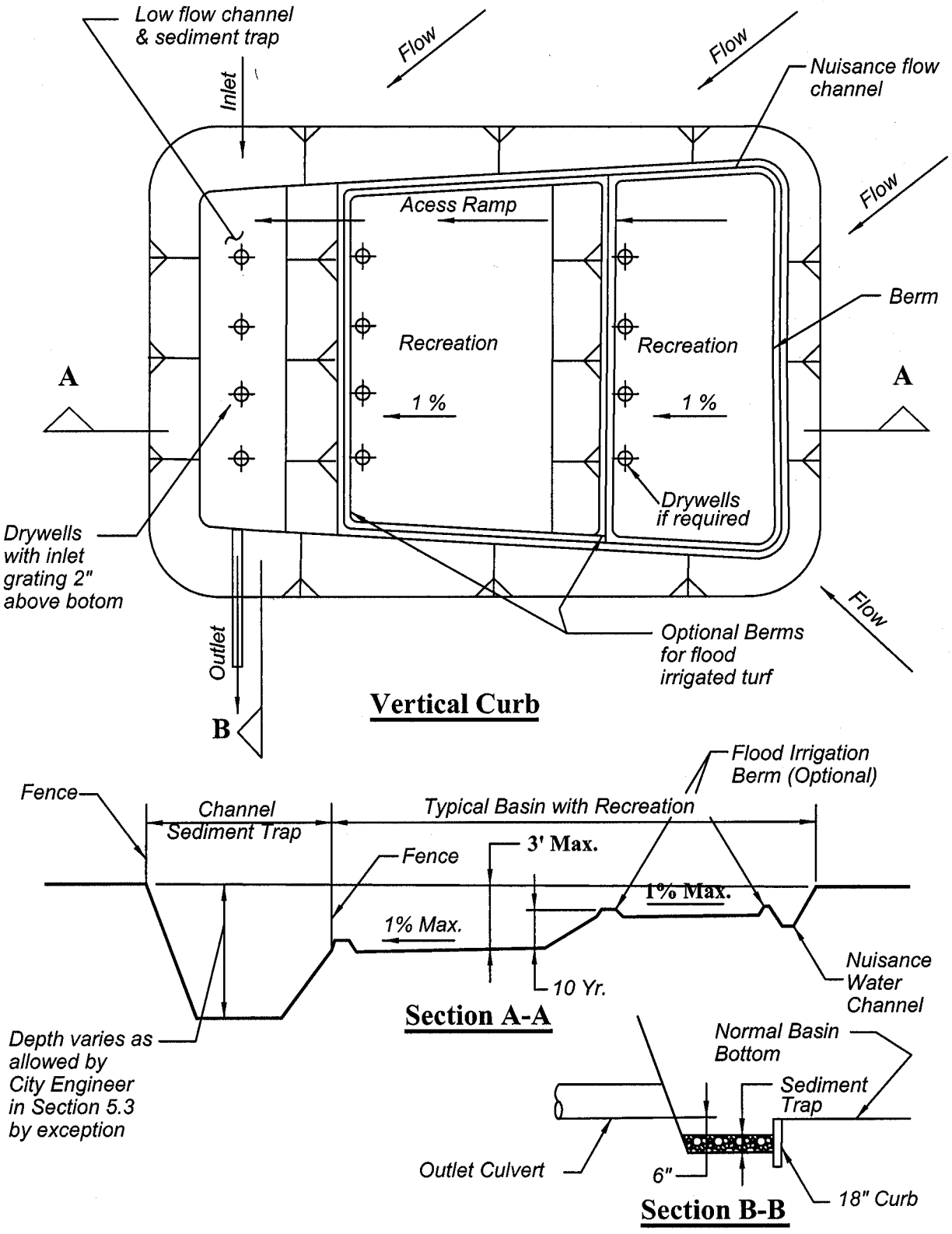


Figure 5-1
Typical Cross Section of Retention Basin With Recreational Area and Sediment Trap

5.4 Temporary Retention Basins

New site developments with roadways are required to provide temporary retention basins to store storm drainage from the roadway until the permanent retention facilities are made operational. Temporary retention basins shall be designed to provide storage for the 100-year, 2-hour storm plus an additional ten (10) percent and shall be graded and configured to provide a minimum 1'-0" of freeboard above the 100-year, 2-hour storm water level. Temporary retention basins are required to store runoff only from the roadway surface; however, scuppers should be sized for the flows anticipated at completion of the development.

4.5 On-Lot Retention Requirements

(For Current Sub-Divisions Only, Jan. 2000)

On-lot retention may be allowed on lots larger than 18,000-square-feet. The Preliminary Drainage Report should include calculations for the largest model (home) on the smallest lot. This should identify any possible retention problems. For weighted coefficients, use 0.95 for roofs, concrete, paving, etc., and 0.5 for landscaping. Set aside 750-square-feet of rear yard for future swimming pool (this area may not be used for retention). Where lots do not provide the required retention, individual lot restrictions will apply as to model size and/or landscaping (for lower coefficients). A coefficient of 0.65 will be used to calculate retention required during the interim, before improvements. The entire subdivision will be designed using a coefficient of 0.65 and no single lot may use a weighted coefficient less than 0.65.

Items to be submitted with building permit applications where lots are subject to on-lot retention:

1. Grading Plan for lot:

   – Show elevations on corners (outfall included), bottom retention, finish floor, and pad.

2. Calculations demonstrating required retention for subject property and half street. Include additional 10 percent for required retention volume.

3. Calculations for weighted coefficients:

   – 0.95 for roof areas, concrete, and pavement.
   – 0.50 for landscaping, unless a landscaping plan is submitted with application.
   – Minimum of 0.65 to be used for overall. (In other words if weighted coefficient is less than 0.65, then 0.65 must be used).

4. Calculations demonstrating provided retention:

   – Square feet for retention area and depth, etc.

5. An area of 750-square feet minimum to be set aside for swimming pool.

6. Copy of Recorded Covenant.

7. Purchasers Disclaimer acknowledging on-lot retention. If the Disclaimer is not available for the Building Permit, it shall become a requirement to obtain Certificate of Occupancy.

8. Requirement to obtain Certificate of Occupancy:

   – Engineer's As-Built certification after lot finish grading is completed.

5.6 Underground Retention Storage Tank Requirements

Underground storage of stormwater may be allowed in commercial or industrial sites. Underground storage is not allowed in apartment, condominium, townhome, or other residential developments.

1. Installation of corrugated metal pipe shall be in accordance with MAG Specification #621 and a note on strutting, spacing, if required, demonstrating that they are within manufacturer's specification and recommendation for installation. Excavation, bedding, and backfill shall be in accordance with MAG Specification #601 and material per MAG Specification #760.

2. A report is required, prepared by an engineer registered in Arizona, showing the depth to groundwater and the depth of the proposed installation. Provide soil boring results to at least 10-feet below the bottom of the proposed installation.

3. Demonstration of a 50-year life of the installation (lining and coating must be specified). Methodology for determining the soil side service life of corrugated steel pipe shall be per the *Soil Side Durability of Corrugated Steel Pipe*, Final Report 1991, prepared for the National Corrugated Steel Pipe Association or per the estimated average service life charts provided in Appendix B.

4. Soil conditions at the proposed location of the underground storage tank shall be investigated. Plans shall include the results of the soil investigation and shall provide data for the following parameters:

   a. Soil pH
   b. Resistivity in ohm-cm
   c. Chloride concentration in ppm
   d. Sulfate concentration in ppm
   e. Moisture content

5. Traffic/load bearing capacity of the installation (pipe gage and corrugation size of corrugated metal pipe and D-Load for reinforced concrete pipe must be specified).

6. A detail of how the installation will be drained into the dry well. City of Chandler drywell detail does not address anything other than normal installation. The sedimentation chamber and drain must be lower than the tank drain so the tank drains completely.

7. Provide a backfill detail. Include material and compaction requirements, particularly under the haunches and to the springline.

8. Provide a minimum of 2 access points into each tank. Forty-eight inch minimum manhole shafts at each access point into the underground pipe with installed fixed ladders using the end walls as anchors (to do this, we will have to be assured by the Structural Engineer or manufacturer that structural integrity is not jeopardized). A 30-inch manhole frame and cover can be used at grade - with concrete collar where subject to wheel loads.

9. Provide assurance that the material used for the piping is suitable for the site's soil (letter from the Soils Engineer).

10. Specify watertight manufactured joints.

11. Provide end walls for pipe per manufacturer(s) recommendation with a detail.

12. Cover to be 3-feet minimum in traffic areas (or manufacturer(s) recommendation).

13. RGRCP is suggested for strength and durability. Structural strength calculations, based on subgrade capacity, are required in areas subject to wheel loads.

14. Connection details are required for manhole shafts, end walls, inlet and outlet pipe connections, end structures etc. and shall be designed by a registered structural engineer who shall certify that his/her design is in conformance with the U.B.C. (currently adopted by the City) and shall further certify that the construction is in conformance with his/her design.

Section 6.0
Disposal of Stormwater

6.1 Retention Basins

Retention basins are required to drain within a 36-hour period by infiltration or drywell. Shallow pit percolation tests shall be performed in each retention basin location, as described in the City Standard Details, to determine natural percolation. The tests shall be performed 3 feet below natural ground or at the elevation of the bottom of the retention basin, whichever is lower, per C.O.C. Std. Detail C-109. Test results shall be submitted to the City Engineer prior to approval of drainage plans.

To calculate the retention time in a basin, use 50 percent of the tested percolation rate to allow for degradation. Test results and calculations determining time of disposal shall be included in a drainage report prior to plan approval, mass grading, or other site disturbance. Drywell Details C-501 and C-502 shall be reproduced on the plans.

6.2 Drywells

Drywells are permitted to drain surface retention areas only when no other means of disposal are available. Infiltration into the drywell cannot be considered to reduce the size of the retention area. The property owner of record shall be responsible for the design, performance, operation, or maintenance of drywells used with on-site retention. Drywells must penetrate at least 10 feet into a permeable stratum and a percolation test must be carried out on the drywell before acceptance. The percolation test results are to be filed with the City Engineer. Drywells shall comply with the Arizona Department of Environmental Quality (ADEQ) publication *Guidance for Design, Installation, Operation, Maintenance, and Inspection of Drywells* and the additional requirements described herein. A copy of the application for registration by ADEQ of the proposed drywell shall be submitted prior to approval of grading plans.

Drywells may be installed when percolation tests reveal natural infiltration rates will exceed a 36-hour period for disposal and there are no other means of disposal available. A maximum disposal rate of 0.1 cubic feet per second (cfs) may be used for estimating the number of drywells required. All drywells are to be shown on Grading Plans along with a corresponding number (Drywell #1, Drywell #2, etc.).

Multiple drywell installations shall be located a minimum of 100-feet apart, unless waived by the City Engineer, and a minimum of 20-feet away from a basin inlet. All drywells receiving stormwater directly from paved areas or drain areas containing fuel or oil storage and dispensing facilities must have oil interceptors installed on them, per C.O.C. Std. Detail C-502. Drywells shall be located a minimum of 100-feet away from water wells, underground storage tanks.

Top of the drywell grate shall be set 2" above the bottom elevation of the retention basin. Drywells must penetrate at least 10-feet into a permeable stratum and a percolation test must be carried out on the drywell before acceptance. All drywells shall conform to City Standard Detail C-501 or C-

502. Detail C-502 shall be used for drywells located in a retention basin which receives runoff from a gasoline filling station or other petroleum storage or dispensing facility. Number and type of drywell are to be called out on the engineering plans. Single chamber drywells are not acceptable. Each drywell will be tested after installation and a 50 percent value of its disposal rate shall be used, up to but not exceeding 0.5 cfs. The percolation test results are to be submitted to the City Engineer with the final as built drawings of the stormwater collection and retention plan.

Drywells shall have a minimum settling capacity of 1,000 cubic feet per chamber, inlet weir plate for oil separation, and a petrochemical absorbent.

Drywells which encounter perched water shall be sealed in the perched water zone of the well.

All drywells shall be registered with the ADEQ and constructed by an ADEQ licensed contractor. The approved drywell registration shall be submitted to the City by the developer or his engineer at the time As-Builts are submitted. A tabulation showing drywell number, registration number, and percolation rate will be added to Grading Plan coversheet before submitting As-Builts.

The property owner of record shall be responsible for the design, performance, operation, and maintenance of drywells used with on-site retention. Drywells that cease to drain a project area in a 36-hour period shall be replaced by the maintenance authority with new ones. Drywells are not to be located within public street right-of-way or private street roadway tracts unless authorized by the City Engineer. One drywell 36 hours: 12,960 cubic feet, 0.298 acre-feet.

6.3 Pump Stations

Pump stations shall comply with the requirements of Chapter 9 of Volume 2 of the FCDMC Drainage Design Manual, except as noted below.

1. Pumping facilities shall be set at an elevation at or above the anticipated level of the 100-year event, considering that a total power failure may occur.

2. Pumps shall be capable of handling solids up to a maximum of 3 inches.

3. Screening devices will not be used at the entrances to the pump station. Grates will be used on each catch basin.

Section 7
Miscellaneous Requirements

7.1 Guardrails

Stormwater structures such as head walls, retaining walls, etc., which present a fall hazard of 30 inches or greater shall have guardrails per City Standard Detail C-107.

Section 8
Maintenance Standards

8.1 General

All drainage control, flood control, and erosion control facilities, both public and private, shall be regularly maintained. Accumulations of silt, trash, litter, or stagnant water which create a health or safety hazard or which endanger the design function of the facility are not permitted. Excessive growth or accumulation of woody vegetation in channels and on dams and levees shall not be permitted. Active erosion due to wind or water associated with drainage control, flood control, and erosion control facilities shall not be permitted.

The City shall regularly maintain the drainage control, flood control, and erosion control facilities for which it has responsibility.

Privately owned drainage control, flood control, and erosion control facilities shall be maintained according to the general standards above and such that adjacent upstream or downstream public or private facilities are not damaged or endangered.

8.2 Detention Basins

Detention basin silt removal should occur when the accumulated depth exceeds 6 inches on average in basins without sediment traps. In basins with sediment traps, silt removal should occur when accumulation exceeds 4 inches. Detention basin surfaces which are non-vegetated shall be scarified to breakup silt deposits and surface crusting on an annual basis. Use of heavy equipment for basin maintenance can cause excessive compaction of the basin surface and its use is discouraged for basin maintenance.

8.3 Drywells

Drywells are highly susceptible to loss of effectiveness due to clogging of well screens and silt accumulation in the drainage rock. Clogging well screens can be caused by chemical encrustation of well screen materials by water soluble minerals compounded by alternating cycles of wetting and drying. Drywell efficiency can be restored by periodic jetting with water and compressed air to remove silt.

The inlet chamber of the City Standard Dual Chamber Drywell serves as a trap for heavy sediments and trash. Inlet chambers should be cleaned periodically as described below. The amount of sediment which deposits in the inlet chamber can be significantly reduced by maintaining an adequate sediment trap around the drywell inlet.

8.3.1 Drywell Inspection

Drywell inspections are to be performed annually or whenever ponding is still evident 36 hours after a storm. Inspections shall be documented utilizing ADEQ's inspection checklist and kept on file by the drywell facility owner.

Drywell maintenance shall occur when inspection shows:

1. Ten percent of the drywell capacity is filled with sediment, for drywells in paved areas

2. Twenty-five percent of the drywell capacity is filled with sediment for drywells in landscaped areas

3. Drainage time has increased beyond 36 hours

4. A non-stormwater discharge has entered the well

5. Upon change of ownership of the well

8.3.2 Drywell Maintenance

Drywell maintenance shall include:

1. Removal of dirt and debris

2. Replacement of filter fabrics (if any) and petrochemical absorbent

3. Cleaning of screens

4. Opening of liner weep holes

5. Purging of accumulated silt out of the aggregate fill by jetting, surging, or pumping

Should inspection reveal that a drywell is no longer effective and cannot be returned to effective use, a new drywell shall be installed.

Section 9
References

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Conceptual Engineering Site Review Checklist
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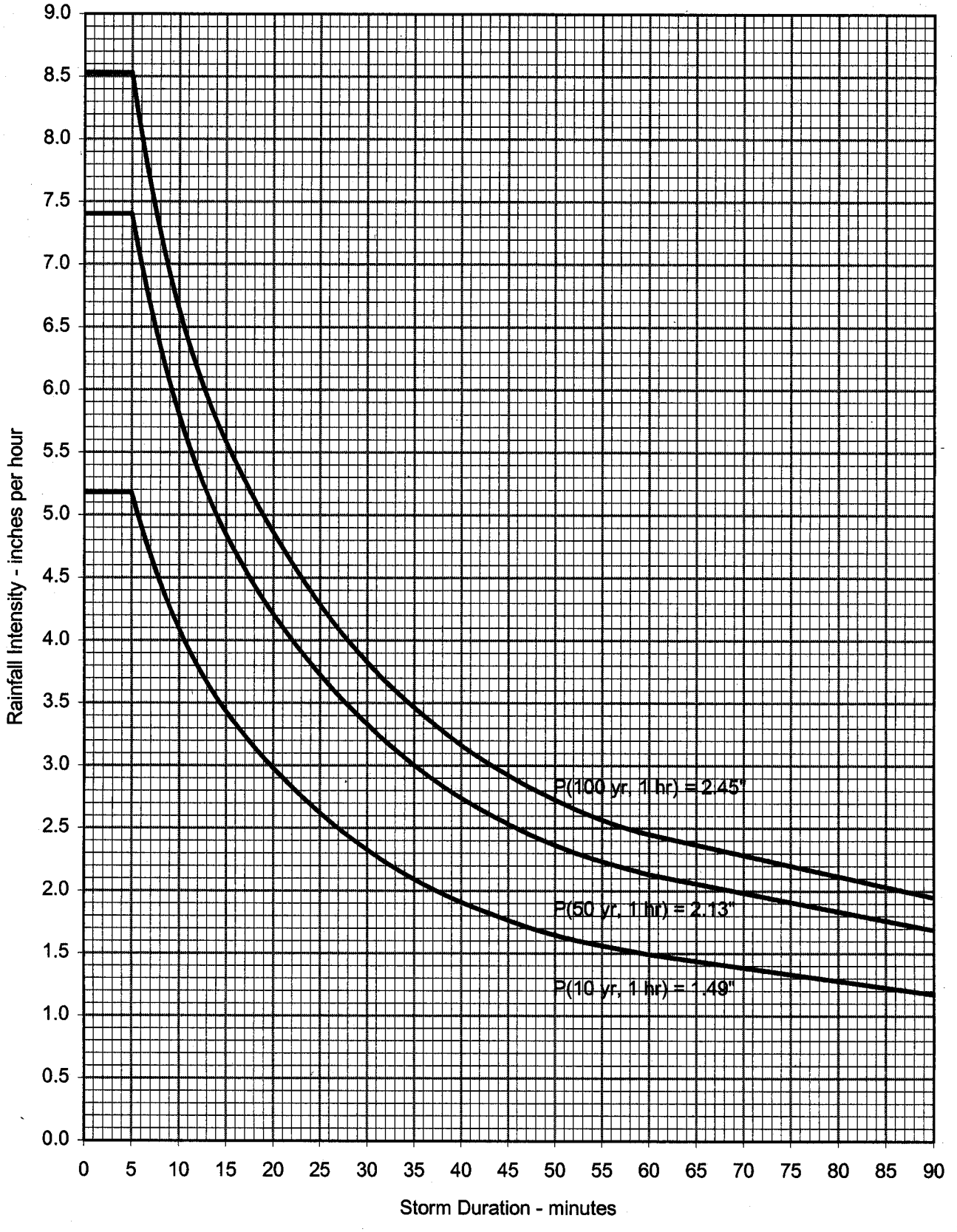
Appendix A
Chandler Standard Rainfall Duration, Intensity, and Frequency Curves

CITY OF CHANDLER
RAINFALL INTENSITY VS. STORM DURATION



CITY OF CHANDLER
RAINFALL INTENSITY

Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i	Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i
minutes	inches/hour	inches/hour	inches/hour	minutes	inches/hour	inches/hour	inches/hour
5.0	5.18	7.40	8.53	9.0	4.27	6.05	6.93
5.1	5.15	7.36	8.48	9.1	4.25	6.03	6.90
5.2	5.12	7.32	8.43	9.2	4.23	6.00	6.87
5.3	5.10	7.28	8.38	9.3	4.21	5.97	6.84
5.4	5.07	7.24	8.33	9.4	4.19	5.95	6.81
5.5	5.04	7.20	8.28	9.5	4.18	5.92	6.78
5.6	5.02	7.16	8.23	9.6	4.16	5.90	6.75
5.7	4.99	7.12	8.19	9.7	4.14	5.87	6.72
5.8	4.96	7.08	8.14	9.8	4.13	5.85	6.70
5.9	4.94	7.04	8.09	9.9	4.11	5.82	6.67
6.0	4.91	7.01	8.05	10.0	4.09	5.80	6.64
6.1	4.89	6.97	8.00	10.1	4.08	5.77	6.61
6.2	4.86	6.93	7.96	10.2	4.06	5.75	6.59
6.3	4.84	6.90	7.91	10.3	4.04	5.73	6.56
6.4	4.81	6.86	7.87	10.4	4.03	5.70	6.53
6.5	4.79	6.82	7.83	10.5	4.01	5.68	6.51
6.6	4.76	6.79	7.79	10.6	4.00	5.66	6.48
6.7	4.74	6.75	7.74	10.7	3.98	5.64	6.46
6.8	4.72	6.72	7.70	10.8	3.97	5.61	6.43
6.9	4.69	6.69	7.66	10.9	3.95	5.59	6.41
7.0	4.67	6.65	7.62	11.0	3.94	5.57	6.38
7.1	4.65	6.62	7.58	11.1	3.92	5.55	6.36
7.2	4.63	6.59	7.55	11.2	3.91	5.53	6.34
7.3	4.60	6.55	7.51	11.3	3.89	5.50	6.31
7.4	4.58	6.52	7.47	11.4	3.88	5.48	6.29
7.5	4.56	6.49	7.43	11.5	3.86	5.46	6.27
7.6	4.54	6.46	7.40	11.6	3.85	5.44	6.24
7.7	4.52	6.43	7.36	11.7	3.83	5.42	6.22
7.8	4.50	6.40	7.32	11.8	3.82	5.40	6.20
7.9	4.48	6.37	7.29	11.9	3.81	5.38	6.18
8.0	4.46	6.34	7.25	12.0	3.79	5.36	6.15
8.1	4.44	6.31	7.22	12.1	3.78	5.34	6.13
8.2	4.42	6.28	7.18	12.2	3.77	5.32	6.11
8.3	4.40	6.25	7.15	12.3	3.75	5.30	6.09
8.4	4.38	6.22	7.12	12.4	3.74	5.28	6.07
8.5	4.36	6.19	7.09	12.5	3.73	5.27	6.05
8.6	4.34	6.16	7.05	12.6	3.71	5.25	6.03
8.7	4.32	6.13	7.02	12.7	3.70	5.23	6.01
8.8	4.30	6.11	6.99	12.8	3.69	5.21	5.99
8.9	4.28	6.08	6.96	12.9	3.68	5.19	5.97

CITY OF CHANDLER
RAINFALL INTENSITY

Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i	Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i
minutes	inches/hour	inches/hour	inches/hour	minutes	inches/hour	inches/hour	inches/hour
13.0	3.66	5.17	5.95	17.0	3.24	4.56	5.27
13.1	3.65	5.16	5.93	17.1	3.23	4.55	5.25
13.2	3.64	5.14	5.91	17.2	3.22	4.54	5.24
13.3	3.63	5.12	5.89	17.3	3.21	4.53	5.22
13.4	3.61	5.10	5.87	17.4	3.20	4.51	5.21
13.5	3.60	5.09	5.85	17.5	3.19	4.50	5.19
13.6	3.59	5.07	5.83	17.6	3.18	4.49	5.18
13.7	3.58	5.05	5.81	17.7	3.17	4.47	5.17
13.8	3.57	5.03	5.79	17.8	3.16	4.46	5.15
13.9	3.56	5.02	5.77	17.9	3.15	4.45	5.14
14.0	3.54	5.00	5.76	18.0	3.14	4.44	5.12
14.1	3.53	4.99	5.74	18.1	3.14	4.43	5.11
14.2	3.52	4.97	5.72	18.2	3.13	4.41	5.10
14.3	3.51	4.95	5.70	18.3	3.12	4.40	5.08
14.4	3.50	4.94	5.69	18.4	3.11	4.39	5.07
14.5	3.49	4.92	5.67	18.5	3.10	4.38	5.06
14.6	3.48	4.91	5.65	18.6	3.09	4.37	5.04
14.7	3.47	4.89	5.63	18.7	3.08	4.35	5.03
14.8	3.46	4.87	5.62	18.8	3.08	4.34	5.01
14.9	3.44	4.86	5.60	18.9	3.07	4.33	5.00
15.0	3.43	4.84	5.58	19.0	3.06	4.32	4.99
15.1	3.42	4.83	5.57	19.1	3.05	4.31	4.97
15.2	3.41	4.81	5.55	19.2	3.04	4.30	4.96
15.3	3.40	4.80	5.53	19.3	3.03	4.29	4.95
15.4	3.39	4.78	5.52	19.4	3.03	4.27	4.94
15.5	3.38	4.77	5.50	19.5	3.02	4.26	4.92
15.6	3.37	4.76	5.48	19.6	3.01	4.25	4.91
15.7	3.36	4.74	5.47	19.7	3.00	4.24	4.90
15.8	3.35	4.73	5.45	19.8	2.99	4.23	4.88
15.9	3.34	4.71	5.44	19.9	2.99	4.22	4.87
16.0	3.33	4.70	5.42	20.0	2.98	4.21	4.86
16.1	3.32	4.68	5.40	20.1	2.97	4.20	4.85
16.2	3.31	4.67	5.39	20.2	2.96	4.19	4.83
16.3	3.30	4.66	5.37	20.3	2.95	4.18	4.82
16.4	3.29	4.64	5.36	20.4	2.95	4.17	4.81
16.5	3.28	4.63	5.34	20.5	2.94	4.16	4.80
16.6	3.27	4.62	5.33	20.6	2.93	4.14	4.78
16.7	3.26	4.60	5.31	20.7	2.92	4.13	4.77
16.8	3.25	4.59	5.30	20.8	2.92	4.12	4.76
16.9	3.24	4.58	5.28	20.9	2.91	4.11	4.75

CITY OF CHANDLER
RAINFALL INTENSITY

Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i	Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i
minutes	inches/hour	inches/hour	inches/hour	minutes	inches/hour	inches/hour	inches/hour
21.0	2.90	4.10	4.73	25.0	2.62	3.73	4.29
21.1	2.89	4.09	4.72	25.1	2.61	3.72	4.28
21.2	2.89	4.08	4.71	25.2	2.61	3.71	4.27
21.3	2.88	4.07	4.70	25.3	2.60	3.70	4.26
21.4	2.87	4.06	4.69	25.4	2.59	3.69	4.25
21.5	2.86	4.05	4.67	25.5	2.59	3.68	4.24
21.6	2.86	4.04	4.66	25.6	2.58	3.67	4.23
21.7	2.85	4.03	4.65	25.7	2.58	3.67	4.22
21.8	2.84	4.02	4.64	25.8	2.57	3.66	4.21
21.9	2.83	4.01	4.63	25.9	2.56	3.65	4.20
22.0	2.83	4.00	4.62	26.0	2.56	3.64	4.19
22.1	2.82	3.99	4.60	26.1	2.55	3.63	4.18
22.2	2.81	3.98	4.59	26.2	2.54	3.62	4.17
22.3	2.80	3.97	4.58	26.3	2.54	3.62	4.16
22.4	2.80	3.96	4.57	26.4	2.53	3.61	4.15
22.5	2.79	3.95	4.56	26.5	2.53	3.60	4.14
22.6	2.78	3.94	4.55	26.6	2.52	3.59	4.13
22.7	2.78	3.94	4.54	26.7	2.51	3.58	4.12
22.8	2.77	3.93	4.52	26.8	2.51	3.58	4.11
22.9	2.76	3.92	4.51	26.9	2.50	3.57	4.10
23.0	2.75	3.91	4.50	27.0	2.50	3.56	4.09
23.1	2.75	3.90	4.49	27.1	2.49	3.55	4.08
23.2	2.74	3.89	4.48	27.2	2.48	3.54	4.07
23.3	2.73	3.88	4.47	27.3	2.48	3.53	4.06
23.4	2.73	3.87	4.46	27.4	2.47	3.53	4.05
23.5	2.72	3.86	4.45	27.5	2.47	3.52	4.04
23.6	2.71	3.85	4.44	27.6	2.46	3.51	4.03
23.7	2.71	3.84	4.42	27.7	2.45	3.50	4.02
23.8	2.70	3.83	4.41	27.8	2.45	3.50	4.02
23.9	2.69	3.82	4.40	27.9	2.44	3.49	4.01
24.0	2.69	3.81	4.39	28.0	2.44	3.48	4.00
24.1	2.68	3.81	4.38	28.1	2.43	3.47	3.99
24.2	2.67	3.80	4.37	28.2	2.42	3.46	3.98
24.3	2.67	3.79	4.36	28.3	2.42	3.46	3.97
24.4	2.66	3.78	4.35	28.4	2.41	3.45	3.96
24.5	2.65	3.77	4.34	28.5	2.41	3.44	3.95
24.6	2.65	3.76	4.33	28.6	2.40	3.43	3.94
24.7	2.64	3.75	4.32	28.7	2.40	3.43	3.94
24.8	2.63	3.74	4.31	28.8	2.39	3.42	3.93
24.9	2.63	3.73	4.30	28.9	2.39	3.41	3.92

CITY OF CHANDLER
RAINFALL INTENSITY

Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i	Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i
minutes	inches/hour	inches/hour	inches/hour	minutes	inches/hour	inches/hour	inches/hour
29.0	2.38	3.40	3.91	33.0	2.18	3.12	3.60
29.1	2.37	3.40	3.90	33.1	2.17	3.12	3.59
29.2	2.37	3.39	3.89	33.2	2.17	3.11	3.58
29.3	2.36	3.38	3.88	33.3	2.16	3.11	3.58
29.4	2.36	3.37	3.88	33.4	2.16	3.10	3.57
29.5	2.35	3.37	3.87	33.5	2.15	3.09	3.56
29.6	2.35	3.36	3.86	33.6	2.15	3.09	3.56
29.7	2.34	3.35	3.85	33.7	2.15	3.08	3.55
29.8	2.34	3.34	3.84	33.8	2.14	3.07	3.54
29.9	2.33	3.34	3.83	33.9	2.14	3.07	3.54
30.0	2.33	3.33	3.83	34.0	2.13	3.06	3.53
30.1	2.32	3.32	3.82	34.1	2.13	3.06	3.52
30.2	2.32	3.32	3.81	34.2	2.12	3.05	3.52
30.3	2.31	3.31	3.80	34.3	2.12	3.04	3.51
30.4	2.30	3.30	3.79	34.4	2.11	3.04	3.50
30.5	2.30	3.29	3.79	34.5	2.11	3.03	3.50
30.6	2.29	3.29	3.78	34.6	2.11	3.03	3.49
30.7	2.29	3.28	3.77	34.7	2.10	3.02	3.48
30.8	2.28	3.27	3.76	34.8	2.10	3.01	3.48
30.9	2.28	3.27	3.75	34.9	2.09	3.01	3.47
31.0	2.27	3.26	3.75	35.0	2.09	3.00	3.46
31.1	2.27	3.25	3.74	35.1	2.09	3.00	3.46
31.2	2.26	3.24	3.73	35.2	2.08	2.99	3.45
31.3	2.26	3.24	3.72	35.3	2.08	2.98	3.44
31.4	2.25	3.23	3.71	35.4	2.07	2.98	3.44
31.5	2.25	3.22	3.71	35.5	2.07	2.97	3.43
31.6	2.24	3.22	3.70	35.6	2.06	2.97	3.42
31.7	2.24	3.21	3.69	35.7	2.06	2.96	3.42
31.8	2.23	3.20	3.68	35.8	2.06	2.95	3.41
31.9	2.23	3.20	3.68	35.9	2.05	2.95	3.40
32.0	2.22	3.19	3.67	36.0	2.05	2.94	3.40
32.1	2.22	3.18	3.66	36.1	2.04	2.94	3.39
32.2	2.21	3.18	3.66	36.2	2.04	2.93	3.39
32.3	2.21	3.17	3.65	36.3	2.04	2.93	3.38
32.4	2.21	3.16	3.64	36.4	2.03	2.92	3.37
32.5	2.20	3.16	3.63	36.5	2.03	2.92	3.37
32.6	2.20	3.15	3.63	36.6	2.03	2.91	3.36
32.7	2.19	3.14	3.62	36.7	2.02	2.90	3.36
32.8	2.19	3.14	3.61	36.8	2.02	2.90	3.35
32.9	2.18	3.13	3.60	36.9	2.01	2.89	3.34

CITY OF CHANDLER
RAINFALL INTENSITY

Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i	Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i
minutes	inches/hour	inches/hour	inches/hour	minutes	inches/hour	inches/hour	inches/hour
37.0	2.01	2.89	3.34	41.0	1.88	2.69	3.11
37.1	2.01	2.88	3.33	41.1	1.87	2.69	3.10
37.2	2.00	2.88	3.33	41.2	1.87	2.69	3.10
37.3	2.00	2.87	3.32	41.3	1.87	2.68	3.09
37.4	2.00	2.87	3.31	41.4	1.87	2.68	3.09
37.5	1.99	2.86	3.31	41.5	1.86	2.67	3.08
37.6	1.99	2.86	3.30	41.6	1.86	2.67	3.08
37.7	1.98	2.85	3.30	41.7	1.86	2.67	3.07
37.8	1.98	2.85	3.29	41.8	1.85	2.66	3.07
37.9	1.98	2.84	3.28	41.9	1.85	2.66	3.06
38.0	1.97	2.84	3.28	42.0	1.85	2.65	3.06
38.1	1.97	2.83	3.27	42.1	1.84	2.65	3.05
38.2	1.97	2.83	3.27	42.2	1.84	2.64	3.05
38.3	1.96	2.82	3.26	42.3	1.84	2.64	3.05
38.4	1.96	2.82	3.25	42.4	1.84	2.64	3.04
38.5	1.96	2.81	3.25	42.5	1.83	2.63	3.04
38.6	1.95	2.81	3.24	42.6	1.83	2.63	3.03
38.7	1.95	2.80	3.24	42.7	1.83	2.62	3.03
38.8	1.95	2.80	3.23	42.8	1.83	2.62	3.02
38.9	1.94	2.79	3.22	42.9	1.82	2.61	3.02
39.0	1.94	2.79	3.22	43.0	1.82	2.61	3.01
39.1	1.94	2.78	3.21	43.1	1.82	2.61	3.01
39.2	1.93	2.78	3.21	43.2	1.81	2.60	3.00
39.3	1.93	2.77	3.20	43.3	1.81	2.60	3.00
39.4	1.93	2.77	3.19	43.4	1.81	2.59	2.99
39.5	1.92	2.76	3.19	43.5	1.81	2.59	2.99
39.6	1.92	2.76	3.18	43.6	1.80	2.59	2.98
39.7	1.92	2.75	3.18	43.7	1.80	2.58	2.98
39.8	1.91	2.75	3.17	43.8	1.80	2.58	2.98
39.9	1.91	2.74	3.17	43.9	1.79	2.57	2.97
40.0	1.91	2.74	3.16	44.0	1.79	2.57	2.97
40.1	1.90	2.73	3.15	44.1	1.79	2.57	2.96
40.2	1.90	2.73	3.15	44.2	1.79	2.56	2.96
40.3	1.90	2.73	3.14	44.3	1.78	2.56	2.95
40.4	1.90	2.72	3.14	44.4	1.78	2.56	2.95
40.5	1.89	2.72	3.13	44.5	1.78	2.55	2.94
40.6	1.89	2.71	3.13	44.6	1.77	2.55	2.94
40.7	1.89	2.71	3.12	44.7	1.77	2.54	2.94
40.8	1.88	2.70	3.12	44.8	1.77	2.54	2.93
40.9	1.88	2.70	3.11	44.9	1.77	2.54	2.93

CITY OF CHANDLER
RAINFALL INTENSITY

Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i	Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i
minutes	inches/hour	inches/hour	inches/hour	minutes	inches/hour	inches/hour	inches/hour
45.0	1.76	2.53	2.92	49.0	1.67	2.39	2.76
45.1	1.76	2.53	2.92	49.1	1.66	2.39	2.76
45.2	1.76	2.52	2.91	49.2	1.66	2.39	2.75
45.3	1.76	2.52	2.91	49.3	1.66	2.38	2.75
45.4	1.75	2.52	2.91	49.4	1.66	2.38	2.75
45.5	1.75	2.51	2.90	49.5	1.65	2.38	2.74
45.6	1.75	2.51	2.90	49.6	1.65	2.37	2.74
45.7	1.74	2.51	2.89	49.7	1.65	2.37	2.74
45.8	1.74	2.50	2.89	49.8	1.65	2.37	2.73
45.9	1.74	2.50	2.88	49.9	1.65	2.37	2.73
46.0	1.74	2.49	2.88	50.0	1.64	2.36	2.73
46.1	1.73	2.49	2.88	50.1	1.64	2.36	2.72
46.2	1.73	2.49	2.87	50.2	1.64	2.36	2.72
46.3	1.73	2.48	2.87	50.3	1.64	2.35	2.71
46.4	1.73	2.48	2.86	50.4	1.64	2.35	2.71
46.5	1.72	2.48	2.86	50.5	1.63	2.35	2.71
46.6	1.72	2.47	2.86	50.6	1.63	2.34	2.70
46.7	1.72	2.47	2.85	50.7	1.63	2.34	2.70
46.8	1.72	2.47	2.85	50.8	1.63	2.34	2.70
46.9	1.71	2.46	2.84	50.9	1.63	2.34	2.69
47.0	1.71	2.46	2.84	51.0	1.63	2.33	2.69
47.1	1.71	2.46	2.84	51.1	1.62	2.33	2.69
47.2	1.71	2.45	2.83	51.2	1.62	2.33	2.68
47.3	1.70	2.45	2.83	51.3	1.62	2.33	2.68
47.4	1.70	2.45	2.82	51.4	1.62	2.32	2.68
47.5	1.70	2.44	2.82	51.5	1.62	2.32	2.67
47.6	1.70	2.44	2.82	51.6	1.61	2.32	2.67
47.7	1.69	2.44	2.81	51.7	1.61	2.31	2.67
47.8	1.69	2.43	2.81	51.8	1.61	2.31	2.66
47.9	1.69	2.43	2.80	51.9	1.61	2.31	2.66
48.0	1.69	2.43	2.80	52.0	1.61	2.31	2.66
48.1	1.69	2.42	2.80	52.1	1.61	2.30	2.65
48.2	1.68	2.42	2.79	52.2	1.60	2.30	2.65
48.3	1.68	2.42	2.79	52.3	1.60	2.30	2.65
48.4	1.68	2.41	2.78	52.4	1.60	2.30	2.64
48.5	1.68	2.41	2.78	52.5	1.60	2.29	2.64
48.6	1.67	2.41	2.78	52.6	1.60	2.29	2.64
48.7	1.67	2.40	2.77	52.7	1.60	2.29	2.63
48.8	1.67	2.40	2.77	52.8	1.59	2.29	2.63
48.9	1.67	2.40	2.77	52.9	1.59	2.28	2.63

CITY OF CHANDLER
RAINFALL INTENSITY

Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i	Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i
minutes	inches/hour	inches/hour	inches/hour	minutes	inches/hour	inches/hour	inches/hour
53.0	1.59	2.28	2.62	57.0	1.53	2.19	2.51
53.1	1.59	2.28	2.62	57.1	1.53	2.19	2.51
53.2	1.59	2.28	2.62	57.2	1.53	2.19	2.51
53.3	1.59	2.27	2.61	57.3	1.53	2.18	2.51
53.4	1.58	2.27	2.61	57.4	1.53	2.18	2.50
53.5	1.58	2.27	2.61	57.5	1.53	2.18	2.50
53.6	1.58	2.27	2.61	57.6	1.52	2.18	2.50
53.7	1.58	2.26	2.60	57.7	1.52	2.18	2.50
53.8	1.58	2.26	2.60	57.8	1.52	2.17	2.49
53.9	1.58	2.26	2.60	57.9	1.52	2.17	2.49
54.0	1.57	2.26	2.59	58.0	1.52	2.17	2.49
54.1	1.57	2.25	2.59	58.1	1.52	2.17	2.49
54.2	1.57	2.25	2.59	58.2	1.52	2.17	2.49
54.3	1.57	2.25	2.58	58.3	1.51	2.16	2.48
54.4	1.57	2.25	2.58	58.4	1.51	2.16	2.48
54.5	1.57	2.24	2.58	58.5	1.51	2.16	2.48
54.6	1.57	2.24	2.58	58.6	1.51	2.16	2.48
54.7	1.56	2.24	2.57	58.7	1.51	2.16	2.47
54.8	1.56	2.24	2.57	58.8	1.51	2.15	2.47
54.9	1.56	2.24	2.57	58.9	1.51	2.15	2.47
55.0	1.56	2.23	2.57	59.0	1.50	2.15	2.47
55.1	1.56	2.23	2.56	59.1	1.50	2.15	2.47
55.2	1.56	2.23	2.56	59.2	1.50	2.15	2.46
55.3	1.56	2.23	2.56	59.3	1.50	2.14	2.46
55.4	1.55	2.22	2.55	59.4	1.50	2.14	2.46
55.5	1.55	2.22	2.55	59.5	1.50	2.14	2.46
55.6	1.55	2.22	2.55	59.6	1.50	2.14	2.46
55.7	1.55	2.22	2.55	59.7	1.49	2.14	2.46
55.8	1.55	2.22	2.54	59.8	1.49	2.13	2.45
55.9	1.55	2.21	2.54	59.9	1.49	2.13	2.45
56.0	1.55	2.21	2.54	60.0	1.49	2.13	2.45
56.1	1.54	2.21	2.54	60.1	1.49	2.13	2.45
56.2	1.54	2.21	2.53	60.2	1.49	2.13	2.45
56.3	1.54	2.20	2.53	60.3	1.49	2.13	2.44
56.4	1.54	2.20	2.53	60.4	1.49	2.12	2.44
56.5	1.54	2.20	2.53	60.5	1.48	2.12	2.44
56.6	1.54	2.20	2.52	60.6	1.48	2.12	2.44
56.7	1.54	2.20	2.52	60.7	1.48	2.12	2.44
56.8	1.53	2.19	2.52	60.8	1.48	2.12	2.44
56.9	1.53	2.19	2.52	60.9	1.48	2.12	2.43

CITY OF CHANDLER
RAINFALL INTENSITY

Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i	Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i
minutes	inches/hour	inches/hour	inches/hour	minutes	inches/hour	inches/hour	inches/hour
61.0	1.48	2.12	2.43	65.0	1.44	2.06	2.37
61.1	1.48	2.11	2.43	65.1	1.44	2.05	2.36
61.2	1.48	2.11	2.43	65.2	1.43	2.05	2.36
61.3	1.48	2.11	2.43	65.3	1.43	2.05	2.36
61.4	1.48	2.11	2.43	65.4	1.43	2.05	2.36
61.5	1.47	2.11	2.42	65.5	1.43	2.05	2.36
61.6	1.47	2.11	2.42	65.6	1.43	2.05	2.36
61.7	1.47	2.10	2.42	65.7	1.43	2.05	2.35
61.8	1.47	2.10	2.42	65.8	1.43	2.04	2.35
61.9	1.47	2.10	2.42	65.9	1.43	2.04	2.35
62.0	1.47	2.10	2.42	66.0	1.43	2.04	2.35
62.1	1.47	2.10	2.41	66.1	1.43	2.04	2.35
62.2	1.47	2.10	2.41	66.2	1.42	2.04	2.35
62.3	1.47	2.10	2.41	66.3	1.42	2.04	2.34
62.4	1.46	2.09	2.41	66.4	1.42	2.04	2.34
62.5	1.46	2.09	2.41	66.5	1.42	2.03	2.34
62.6	1.46	2.09	2.41	66.6	1.42	2.03	2.34
62.7	1.46	2.09	2.40	66.7	1.42	2.03	2.34
62.8	1.46	2.09	2.40	66.8	1.42	2.03	2.34
62.9	1.46	2.09	2.40	66.9	1.42	2.03	2.33
63.0	1.46	2.09	2.40	67.0	1.42	2.03	2.33
63.1	1.46	2.08	2.40	67.1	1.41	2.03	2.33
63.2	1.46	2.08	2.40	67.2	1.41	2.02	2.33
63.3	1.46	2.08	2.39	67.3	1.41	2.02	2.33
63.4	1.45	2.08	2.39	67.4	1.41	2.02	2.33
63.5	1.45	2.08	2.39	67.5	1.41	2.02	2.32
63.6	1.45	2.08	2.39	67.6	1.41	2.02	2.32
63.7	1.45	2.08	2.39	67.7	1.41	2.02	2.32
63.8	1.45	2.07	2.39	67.8	1.41	2.01	2.32
63.9	1.45	2.07	2.38	67.9	1.41	2.01	2.32
64.0	1.45	2.07	2.38	68.0	1.41	2.01	2.32
64.1	1.45	2.07	2.38	68.1	1.40	2.01	2.31
64.2	1.45	2.07	2.38	68.2	1.40	2.01	2.31
64.3	1.44	2.07	2.38	68.3	1.40	2.01	2.31
64.4	1.44	2.07	2.38	68.4	1.40	2.01	2.31
64.5	1.44	2.06	2.37	68.5	1.40	2.00	2.31
64.6	1.44	2.06	2.37	68.6	1.40	2.00	2.31
64.7	1.44	2.06	2.37	68.7	1.40	2.00	2.30
64.8	1.44	2.06	2.37	68.8	1.40	2.00	2.30
64.9	1.44	2.06	2.37	68.9	1.40	2.00	2.30

CITY OF CHANDLER
RAINFALL INTENSITY

Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i	Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i
minutes	inches/hour	inches/hour	inches/hour	minutes	inches/hour	inches/hour	inches/hour
69.0	1.39	2.00	2.30	73.0	1.35	1.94	2.23
69.1	1.39	2.00	2.30	73.1	1.35	1.94	2.23
69.2	1.39	1.99	2.30	73.2	1.35	1.94	2.23
69.3	1.39	1.99	2.29	73.3	1.35	1.93	2.23
69.4	1.39	1.99	2.29	73.4	1.35	1.93	2.23
69.5	1.39	1.99	2.29	73.5	1.35	1.93	2.22
69.6	1.39	1.99	2.29	73.6	1.35	1.93	2.22
69.7	1.39	1.99	2.29	73.7	1.34	1.93	2.22
69.8	1.39	1.99	2.29	73.8	1.34	1.93	2.22
69.9	1.39	1.98	2.28	73.9	1.34	1.92	2.22
70.0	1.38	1.98	2.28	74.0	1.34	1.92	2.22
70.1	1.38	1.98	2.28	74.1	1.34	1.92	2.21
70.2	1.38	1.98	2.28	74.2	1.34	1.92	2.21
70.3	1.38	1.98	2.28	74.3	1.34	1.92	2.21
70.4	1.38	1.98	2.28	74.4	1.34	1.92	2.21
70.5	1.38	1.97	2.27	74.5	1.34	1.92	2.21
70.6	1.38	1.97	2.27	74.6	1.34	1.91	2.21
70.7	1.38	1.97	2.27	74.7	1.33	1.91	2.20
70.8	1.38	1.97	2.27	74.8	1.33	1.91	2.20
70.9	1.37	1.97	2.27	74.9	1.33	1.91	2.20
71.0	1.37	1.97	2.27	75.0	1.33	1.91	2.20
71.1	1.37	1.97	2.26	75.1	1.33	1.91	2.20
71.2	1.37	1.96	2.26	75.2	1.33	1.91	2.20
71.3	1.37	1.96	2.26	75.3	1.33	1.90	2.19
71.4	1.37	1.96	2.26	75.4	1.33	1.90	2.19
71.5	1.37	1.96	2.26	75.5	1.33	1.90	2.19
71.6	1.37	1.96	2.26	75.6	1.32	1.90	2.19
71.7	1.37	1.96	2.25	75.7	1.32	1.90	2.19
71.8	1.36	1.96	2.25	75.8	1.32	1.90	2.19
71.9	1.36	1.95	2.25	75.9	1.32	1.90	2.18
72.0	1.36	1.95	2.25	76.0	1.32	1.89	2.18
72.1	1.36	1.95	2.25	76.1	1.32	1.89	2.18
72.2	1.36	1.95	2.25	76.2	1.32	1.89	2.18
72.3	1.36	1.95	2.24	76.3	1.32	1.89	2.18
72.4	1.36	1.95	2.24	76.4	1.32	1.89	2.18
72.5	1.36	1.95	2.24	76.5	1.32	1.89	2.17
72.6	1.36	1.94	2.24	76.6	1.31	1.88	2.17
72.7	1.36	1.94	2.24	76.7	1.31	1.88	2.17
72.8	1.35	1.94	2.24	76.8	1.31	1.88	2.17
72.9	1.35	1.94	2.23	76.9	1.31	1.88	2.17

CITY OF CHANDLER
RAINFALL INTENSITY

Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i	Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i
minutes	inches/hour	inches/hour	inches/hour	minutes	inches/hour	inches/hour	inches/hour
77.0	1.31	1.88	2.17	81.0	1.27	1.82	2.10
77.1	1.31	1.88	2.16	81.1	1.27	1.82	2.10
77.2	1.31	1.88	2.16	81.2	1.27	1.82	2.09
77.3	1.31	1.87	2.16	81.3	1.26	1.82	2.09
77.4	1.31	1.87	2.16	81.4	1.26	1.81	2.09
77.5	1.30	1.87	2.16	81.5	1.26	1.81	2.09
77.6	1.30	1.87	2.16	81.6	1.26	1.81	2.09
77.7	1.30	1.87	2.15	81.7	1.26	1.81	2.09
77.8	1.30	1.87	2.15	81.8	1.26	1.81	2.08
77.9	1.30	1.87	2.15	81.9	1.26	1.81	2.08
78.0	1.30	1.86	2.15	82.0	1.26	1.81	2.08
78.1	1.30	1.86	2.15	82.1	1.26	1.80	2.08
78.2	1.30	1.86	2.15	82.2	1.25	1.80	2.08
78.3	1.30	1.86	2.14	82.3	1.25	1.80	2.08
78.4	1.29	1.86	2.14	82.4	1.25	1.80	2.07
78.5	1.29	1.86	2.14	82.5	1.25	1.80	2.07
78.6	1.29	1.86	2.14	82.6	1.25	1.80	2.07
78.7	1.29	1.85	2.14	82.7	1.25	1.79	2.07
78.8	1.29	1.85	2.14	82.8	1.25	1.79	2.07
78.9	1.29	1.85	2.13	82.9	1.25	1.79	2.07
79.0	1.29	1.85	2.13	83.0	1.25	1.79	2.06
79.1	1.29	1.85	2.13	83.1	1.25	1.79	2.06
79.2	1.29	1.85	2.13	83.2	1.24	1.79	2.06
79.3	1.29	1.85	2.13	83.3	1.24	1.79	2.06
79.4	1.28	1.84	2.13	83.4	1.24	1.78	2.06
79.5	1.28	1.84	2.12	83.5	1.24	1.78	2.06
79.6	1.28	1.84	2.12	83.6	1.24	1.78	2.05
79.7	1.28	1.84	2.12	83.7	1.24	1.78	2.05
79.8	1.28	1.84	2.12	83.8	1.24	1.78	2.05
79.9	1.28	1.84	2.12	83.9	1.24	1.78	2.05
80.0	1.28	1.83	2.12	84.0	1.24	1.78	2.05
80.1	1.28	1.83	2.11	84.1	1.23	1.77	2.05
80.2	1.28	1.83	2.11	84.2	1.23	1.77	2.04
80.3	1.27	1.83	2.11	84.3	1.23	1.77	2.04
80.4	1.27	1.83	2.11	84.4	1.23	1.77	2.04
80.5	1.27	1.83	2.11	84.5	1.23	1.77	2.04
80.6	1.27	1.83	2.10	84.6	1.23	1.77	2.04
80.7	1.27	1.82	2.10	84.7	1.23	1.77	2.04
80.8	1.27	1.82	2.10	84.8	1.23	1.76	2.03
80.9	1.27	1.82	2.10	84.9	1.23	1.76	2.03

CITY OF CHANDLER
RAINFALL INTENSITY

Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i	Time of Concentration Tc	10-Year Rainfall Intensity i	50-Year Rainfall Intensity i	100-Year Rainfall Intensity i
minutes	inches/hour	inches/hour	inches/hour	minutes	inches/hour	inches/hour	inches/hour
85.0	1.23	1.76	2.03	89.0	1.18	1.70	1.96
85.1	1.22	1.76	2.03	89.1	1.18	1.70	1.96
85.2	1.22	1.76	2.03	89.2	1.18	1.70	1.96
85.3	1.22	1.76	2.03	89.3	1.18	1.70	1.96
85.4	1.22	1.75	2.02	89.4	1.18	1.70	1.96
85.5	1.22	1.75	2.02	89.5	1.18	1.69	1.96
85.6	1.22	1.75	2.02	89.6	1.18	1.69	1.95
85.7	1.22	1.75	2.02	89.7	1.18	1.69	1.95
85.8	1.22	1.75	2.02	89.8	1.17	1.69	1.95
85.9	1.22	1.75	2.02	89.9	1.17	1.69	1.95
86.0	1.21	1.75	2.01	90.0	1.17	1.69	1.95
86.1	1.21	1.74	2.01				
86.2	1.21	1.74	2.01				
86.3	1.21	1.74	2.01				
86.4	1.21	1.74	2.01				
86.5	1.21	1.74	2.01				
86.6	1.21	1.74	2.00				
86.7	1.21	1.74	2.00				
86.8	1.21	1.73	2.00				
86.9	1.20	1.73	2.00				
87.0	1.20	1.73	2.00				
87.1	1.20	1.73	2.00				
87.2	1.20	1.73	1.99				
87.3	1.20	1.73	1.99				
87.4	1.20	1.73	1.99				
87.5	1.20	1.72	1.99				
87.6	1.20	1.72	1.99				
87.7	1.20	1.72	1.99				
87.8	1.20	1.72	1.98				
87.9	1.19	1.72	1.98				
88.0	1.19	1.72	1.98				
88.1	1.19	1.72	1.98				
88.2	1.19	1.71	1.98				
88.3	1.19	1.71	1.98				
88.4	1.19	1.71	1.97				
88.5	1.19	1.71	1.97				
88.6	1.19	1.71	1.97				
88.7	1.19	1.71	1.97				
88.8	1.18	1.70	1.97				
88.9	1.18	1.70	1.97				

Appendix B
Estimated Service Life of Buried Corrugated and Spiral Rib Pipe

CHART FOR ESTIMATING AVERAGE SERVICE LIFE OF CORRUGATED ALUMINIZED STEEL PIPE (CASP), AND SPIRAL RIB ALUMINIZED STEEL PIPE (SRASP).

(COPIED FROM AISI CHART) - (FOR DRY SOIL CONDITIONS)

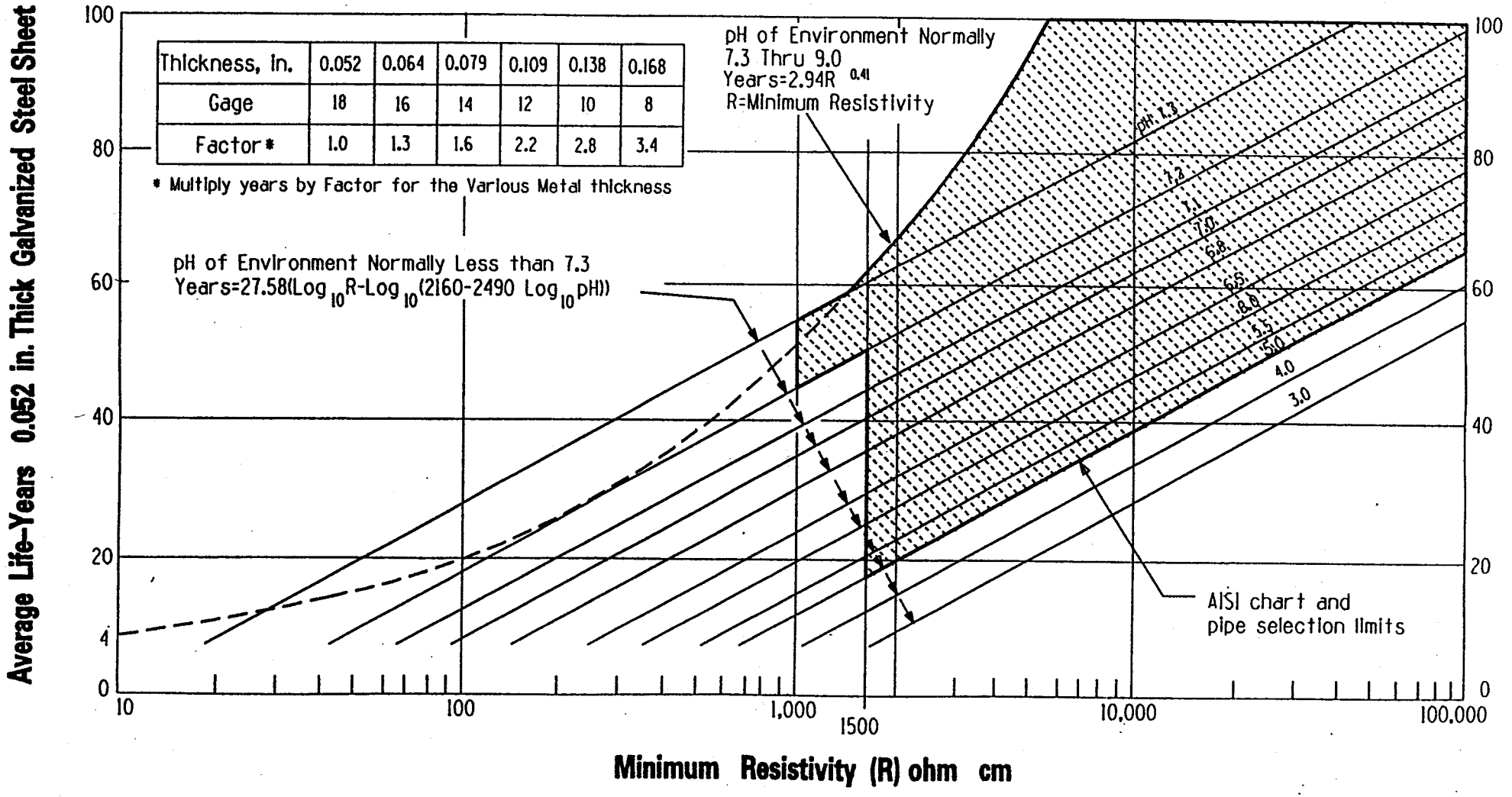


CHART FOR ESTIMATING AVERAGE SERVICE LIFE OF CORRUGATED GALVANIZED STEEL PIPE (CGSP), SPIRAL RIB GALVANIZED STEEL PIPE (SRGSP), AND CORRUGATED GALVANIZED STEEL STRUCTURAL PLATE PIPE (CGSSPP).

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